

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

Search for TeV-scale gravity signatures in high-mass final states with leptons and jets with the ATLAS detector at $\sqrt{s} = 13$ TeV

The ATLAS Collaboration ^{*}

ARTICLE INFO

Article history:

Received 8 June 2016

Received in revised form 7 July 2016

Accepted 11 July 2016

Available online 15 July 2016

Editor: W.-D. Schlatter

ABSTRACT

A search for physics beyond the Standard Model, in final states with at least one high transverse momentum charged lepton (electron or muon) and two additional high transverse momentum leptons or jets, is performed using 3.2 fb^{-1} of proton–proton collision data recorded by the ATLAS detector at the Large Hadron Collider in 2015 at $\sqrt{s} = 13$ TeV. The upper end of the distribution of the scalar sum of the transverse momenta of leptons and jets is sensitive to the production of high-mass objects. No excess of events beyond Standard Model predictions is observed. Exclusion limits are set for models of microscopic black holes with two to six extra dimensions.

© 2016 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>). Funded by SCOAP³.

1. Introduction

Models of TeV-scale gravity postulate that the fundamental scale of gravity, M_D , in a higher-dimensional space–time is much lower than is measured in our four-dimensional space–time. In large extra-dimensional models (e.g. the model proposed by Arkani-Hamed, Dimopoulos and Dvali (ADD) [1,2]) there are n additional flat extra dimensions, assumed to be compactified on a torus with a common radius much larger than $1/M_D$. Another class of models (e.g. that of Randall and Sundrum (RS) [3,4]) uses one extra dimension in a highly warped anti-de-Sitter space. Both of these types of model can address the large difference between the scale of electroweak interactions, $\mathcal{O}(0.1 \text{ TeV})$, and that of gravity, the Planck scale, $M_{\text{Pl}} = \mathcal{O}(10^{16} \text{ TeV})$, in a natural way. Interesting signatures are expected in these models in the form of non-perturbative gravitational states such as microscopic black holes [5,6]. Such final states could be produced in proton–proton (pp) interactions at the Large Hadron Collider (LHC) [7]. In the absence of a full theory of quantum gravity, predictions for production cross-sections and decays of black holes rely on semi-classical approximations which are expected to be valid if the mass of the black hole is well above M_D and also higher than the Hawking temperature [8]. A strong rise in the production rate of such states is expected when the energy scale of the interactions reaches the order of M_D . Since the gravitational interaction couples to the

energy–momentum tensor rather than gauge quantum numbers, final states are expected to be populated “democratically”, according to the number of available Standard Model degrees of freedom. For this reason, it is expected that a significant fraction of final states would contain leptons. This search exploits this feature to enhance the signal contribution in comparison with the dominant background at the LHC, which arises from quark and gluon scattering processes forming hadronic final states. Final states with at least three high transverse momentum (p_T) objects are selected, of which at least one must be an electron or muon (leptons in what follows) and the others can be either leptons or hadronic jets. The discriminating variable used in this search, $\sum p_T$, is the scalar sum of the transverse momenta of high p_T objects in an event. The signal is expected to appear at high $\sum p_T$. Searches by ATLAS [9–12] and CMS [13,14] during Run 1 of the LHC did not reveal any significant excesses over expected background levels. An ATLAS analysis [15] of Run-2 data at 13 TeV also found no evidence of new effects in multijet final states. This work extends the reach of the analysis in Ref. [12], performed at a centre-of-mass energy of 8 TeV, with 3.2 fb^{-1} of data recorded by ATLAS in 2015 at 13 TeV. This search is potentially sensitive to other forms of new physics at high-mass and involving the electroweak sector.

2. ATLAS detector

ATLAS [16] is a multipurpose detector with a forward–backward symmetric cylindrical geometry and nearly 4π coverage in solid

^{*} E-mail address: atlas.publications@cern.ch.

angle.¹ The inner detector (ID) utilises fine-granularity pixel and microstrip detectors over the pseudorapidity range $|\eta| < 2.5$ to provide precise track parameter and secondary vertex measurements. For Run 2 of the LHC, a new pixel layer has been added at a radius of 3.3 cm [17]. A gas-filled straw-tube tracker complements the silicon tracker at larger radii. The tracking detectors are immersed in a 2 T magnetic field produced by a thin superconducting solenoid. The electromagnetic (EM) calorimeters employ lead absorbers and use liquid argon as the active medium. The barrel EM calorimeter covers $|\eta| < 1.5$ and the end-cap EM calorimeters cover $1.4 < |\eta| < 3.2$. Hadronic calorimetry in the region $|\eta| < 1.7$ is performed using steel absorbers with scintillator tiles as the active medium. Liquid-argon calorimetry with copper absorbers is used in the hadronic end-cap calorimeters, which cover the region $1.5 < |\eta| < 3.2$. The forward calorimeters ($3.1 < |\eta| < 4.9$) use copper and tungsten as absorber with liquid argon as active material. The muon spectrometer (MS) measures the deflection of muon trajectories in the region $|\eta| < 2.7$, using three stations of precision drift tubes (with cathode strip chambers in the innermost station for $|\eta| > 2.0$) located in a toroidal magnetic field of approximately 0.5 T and 1 T in the central and end-cap regions, respectively. The muon spectrometer is also instrumented with separate trigger chambers covering $|\eta| < 2.4$. Events are selected using a first-level trigger implemented in custom electronics, designed to reduce the event rate down to 100 kHz using a subset of detector information [18]. Software algorithms with access to the full detector information are then used to yield a recorded event rate of about 1 kHz.

3. Analysis

3.1. Signal simulation

Signal samples are generated by using the CHARYBDIS2 1.0.4 generator [19] to simulate the production and decay of rotating black holes in models with $n = 2, 4$ and 6 extra dimensions and values of M_D ranging from 2 TeV to 5 TeV. Black holes are assumed to be produced over a continuous range of mass values above a threshold M_{th} , set so as to avoid the theoretical uncertainties associated with the region close to M_D . The analysis is guided by two benchmark signal models, the first of which has $M_D = 2$ TeV and $M_{th} = 7$ TeV, resulting in a cross-section of 0.72 pb. The second has $M_D = 4$ TeV, $M_{th} = 6$ TeV, and a cross-section of 0.93 pb. In these simulations, no initial-state gravitational radiation is permitted, while the final decay of the black-hole remnant produces a variable number of particles, whose multiplicity is drawn from a Poisson distribution in accordance with the CHARYBDIS2 default. The CTEQ6L1 parton distribution functions (PDFs) used are taken from Ref. [20], while the final-state fragmentation and parton showering is modelled using PYTHIA8 [21]. The detector response is modelled using a fast simulation of the response of the calorimeters [22] and GEANT4 [23] for other parts of the detector. Events from minimum-bias interactions are also simulated with PYTHIA8. They are overlaid on the simulated signal and background events according to the luminosity profile of the recorded data. Interactions within the same bunch crossing as the hard-scattering process and in neighbouring bunch crossings are both simulated and are referred to as pile-up.

¹ ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point (IP) in the centre of the detector and the z -axis along the beam direction. The x -axis points from the IP to the centre of the LHC ring, and the y -axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam direction. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln \tan(\theta/2)$. Object separations are measured using $\Delta R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$.

3.2. Event selection

Events are selected from a sample with an integrated luminosity of $3.2 \pm 0.2 \text{ fb}^{-1}$. The luminosity estimate is derived following the same methodology as that detailed in Ref. [24], from a calibration of the luminosity scale using a pair of x - y beam-separation scans performed in August 2015. The event selection uses the lowest-threshold single-lepton triggers available in each data-taking period with good operational conditions. The single-electron trigger uses a minimum threshold of $E_T = 60$ GeV. The minimum threshold used for the single-muon trigger is $p_T = 50$ GeV. All the final-state objects are required to satisfy basic criteria to ensure that they are well reconstructed and originate from the primary interaction. Candidate electrons and muons are required to have $p_T > 10$ GeV and pseudorapidity $|\eta| < 2.47$ (electrons) or $|\eta| < 2.5$ (muons). They are also required to satisfy baseline identification criteria (the “Loose” operating point of Ref. [25] for electrons and the “Medium” criteria of Ref. [26] for muons). Jets of hadrons are reconstructed using the anti- k_t algorithm with a radius parameter of 0.4 [27] and are required to be of at least “loose” quality [28] and to have a calibrated [29] $p_T > 20$ GeV and $|\eta| < 2.8$. Jets containing b -hadrons are identified using the “ b -tagging” techniques described in Refs. [30,31]. To avoid double-counting of reconstructed objects, electrons sharing an inner detector track with a muon are removed. Following this, jet candidates that are not b -tagged are removed if they are within $\Delta R < 0.2$ of an electron candidate. Finally, lepton candidates are removed if they lie within $\Delta R < 0.4$ of a surviving jet candidate that is not tagged as originating from pile-up [32]. The remaining electrons are required to satisfy the “Tight” operating point of Ref. [25]. Leptons are required to be isolated from other activity using a relatively loose criterion designed to pass 99% of leptons from Z decays [26,33]. Events are sorted into electron and muon channels according to the flavour of the highest p_T lepton. Two signal regions (SRs) are defined, requiring a leading lepton with $p_T > 100$ GeV and at least two other objects (leptons or jets) with $p_T > 100$ GeV, with $\sum p_T > 2$ TeV or 3 TeV, where $\sum p_T$ includes all objects in the event with $p_T > 60$ GeV. The first signal region (named SR-2TeV) allows the search to cover the parameter space near the existing limits, while the second (named SR-3TeV) provides sensitivity at the highest $\sum p_T$ accessible. The SR-3TeV selection gives efficiency \times acceptance values for the benchmark signal models of 19% (for the model at $M_D = 2$ TeV, $M_{th} = 7$ TeV) and 8% (for the model at $M_D = 4$ TeV, $M_{th} = 6$ TeV).

3.3. Backgrounds

The dominant backgrounds originate from W and Z boson production associated with hadronic jets ($W + \text{jets}$ and $Z + \text{jets}$) and from $t\bar{t}$ production. For these backgrounds, the distributions in kinematic quantities are predicted by Monte Carlo (MC) simulations, which are normalised to data in dedicated control regions (CRs). Each CR uses selections which enhance the contribution of the relevant background while maintaining a negligible expected signal contribution. Single-top-quark and diboson production processes give small contributions that are estimated directly from simulations, with normalisations taken from Refs. [34,35] and from the generator, respectively. The bosonic background processes are simulated using SHERPA 2.1 [36], while POWHEG [37–39] in conjunction with PYTHIA6 [40] is used for top quark production processes. All these background simulations use the CT10 PDF set [41]. The detector response is modelled using GEANT4. The electron channel also contains background events from hadronic jets which are incorrectly reconstructed as electrons. This background, called “multijet”, is estimated from the data using a sample of

Table 1

Definitions of the signal regions and of the control regions used in the estimate of the W + jets, Z + jets and $t\bar{t}$ backgrounds.

Selection	Control regions			Signal regions
	Z + jets	W + jets	t \bar{t}	
$\sum p_T$	750–1500 GeV			> 2000(3000) GeV
Number of objects (leptons or jets)	≥ 3 objects with $p_T > 60$ GeV			≥ 3 objects with $p_T > 100$ GeV
Leading lepton (electron or muon)	Isolated with $p_T > 60$ GeV			Isolated with $p_T > 100$ GeV
$m_{\ell\ell}$	80–100 GeV	n/a		n/a
E_T^{miss}	n/a	> 60 GeV	n/a	
Number of leptons	= 2, opposite sign same flavour	= 1		≥ 1
Number of b -tagged jets	n/a	= 0	≥ 2	n/a
Number of jets	n/a ≥ 4			

events selected with loosened identification criteria using the Matrix Method [42]. The rate of background muons from hadronic jets is negligible.

The background CR selection criteria are summarised in Table 1. All of the CRs select events with $750 < \sum p_T < 1500$ GeV, including at least three objects with $p_T > 60$ GeV of which one is required to be a lepton. The Z + jets CR additionally requires exactly two leptons with the same flavour and opposite charge and an invariant mass $m_{\ell\ell}$ in the range 80–100 GeV. The W + jets CR requires events with exactly one lepton and a missing transverse momentum E_T^{miss} [43] exceeding 60 GeV. In this CR, in order to suppress background from top quark production, none of the jets may be b -tagged. The $t\bar{t}$ CR also requires exactly one lepton, but there must be at least four jets of which at least two are b -tagged. In order to use information about the shape of the $\sum p_T$ distribution to more accurately constrain the normalisation of the W + jets, Z + jets and $t\bar{t}$ backgrounds in the SRs, each control region is divided into three 250-GeV-wide bins.

3.4. Systematic uncertainties

The systematic uncertainties in the signal and backgrounds include those due to the limited numbers of simulated events and to the measurement of integrated luminosity. Experimental uncertainties arising from the trigger efficiencies, lepton identification and reconstruction procedures, the b -tagging algorithm and the energy calibration of leptons and jets, as well as effects from the jet energy resolution, are also taken into account. Potential mis-modelling by the MC simulations of the W + jets, Z + jets and $t\bar{t}$ backgrounds is quantified by comparing the nominal against alternative simulated samples and PDF sets. For the W + jets and Z + jets backgrounds, simulated by SHERPA, the default renormalisation, factorisation and resummation scales are doubled or halved. The matrix element and parton shower are matched using the CKKW [44] scheme, for which the default scale of 20 GeV is changed to 15 GeV and to 30 GeV. For $t\bar{t}$, uncertainties in the hard scatter and fragmentation are estimated by comparison with alternative generators and parton shower models. Variations of the renormalisation scale and of the amount of initial- and final-state radiation are performed within the nominal generator. Since the overall normalisations of the backgrounds are well constrained by the fits to the data described below, only variations in shape as a function of $\sum p_T$ are relevant. The systematic uncertainty in the predicted yields in both channels of SR-2TeV and SR-3TeV is dominated by the limited sizes of the Monte Carlo samples. The total uncertainties in the SRs are mainly of statistical origin.

4. Results

Results are extracted from profile likelihood fits using three background normalisation parameters for the W + jets, Z + jets and $t\bar{t}$ backgrounds. These normalisation parameters are freely floating in the fits. Nuisance parameters are included in the fits to describe the systematic uncertainties, taking into account the correlations across the processes and regions involved in each fit. A background likelihood fit to all control regions of both lepton channels, assuming no signal contribution, is used to predict the expected yields in validation regions (VRs) and to test the hypothesis that the data is well described with no signal in these regions. The VRs are defined using the same event selections as the signal regions, but in the range $1500 < \sum p_T < 2000$ GeV. As in the CRs, any signal contamination in the VRs is expected to be small, based on previous analyses [12] and on signal simulations. Comparisons between the data and the predictions in the control regions, where the background predictions are adjusted by the background likelihood fit, may be seen in Fig. 1. The MC simulation provides a good description of the CR data, with scale factors of 0.81 ± 0.07 , 1.01 ± 0.08 and 0.95 ± 0.08 for W + jets, Z + jets and $t\bar{t}$ respectively. No significant deviation from the background prediction is observed in the VRs.

Fig. 2 shows the data and background predictions for $\sum p_T$ in the electron and muon channels following the background likelihood fit, with two signal models overlaid. This figure uses the SR selection except for the final requirement on $\sum p_T$. The data are in good agreement with the background prediction across the range of $\sum p_T$ which can be tested with the present data, with the size and pattern of deviations between data and background prediction being consistent with statistical fluctuations and the size of the systematic uncertainties. Table 2 presents the data and background predictions in the signal regions. The number of events observed in SR-3TeV is higher than the background estimate in the electron channel with a p -value of 1% when tested against the background-only hypothesis. The excess is not sufficiently significant to be considered as evidence of any new physics effect. The final results are therefore derived from the combination of the two channels. The observed numbers of events in SR-2TeV and SR-3TeV are 192 and 13 respectively for the combination of the electron and muon channels, to be compared with fitted background predictions of 181 ± 11 and 9.9 ± 1.4 .

Model-independent cross-section upper limits on any potential new physics contribution are obtained from fits to all control regions and to signal regions combining the electron and muon channels, with potential signal contributions included via a freely-floating parameter in those signal regions. Model-independent upper limits of 12.1 fb (3.4 fb) at the 95% confidence level (CL) are set on the maximum observable cross-section (defined as cross-

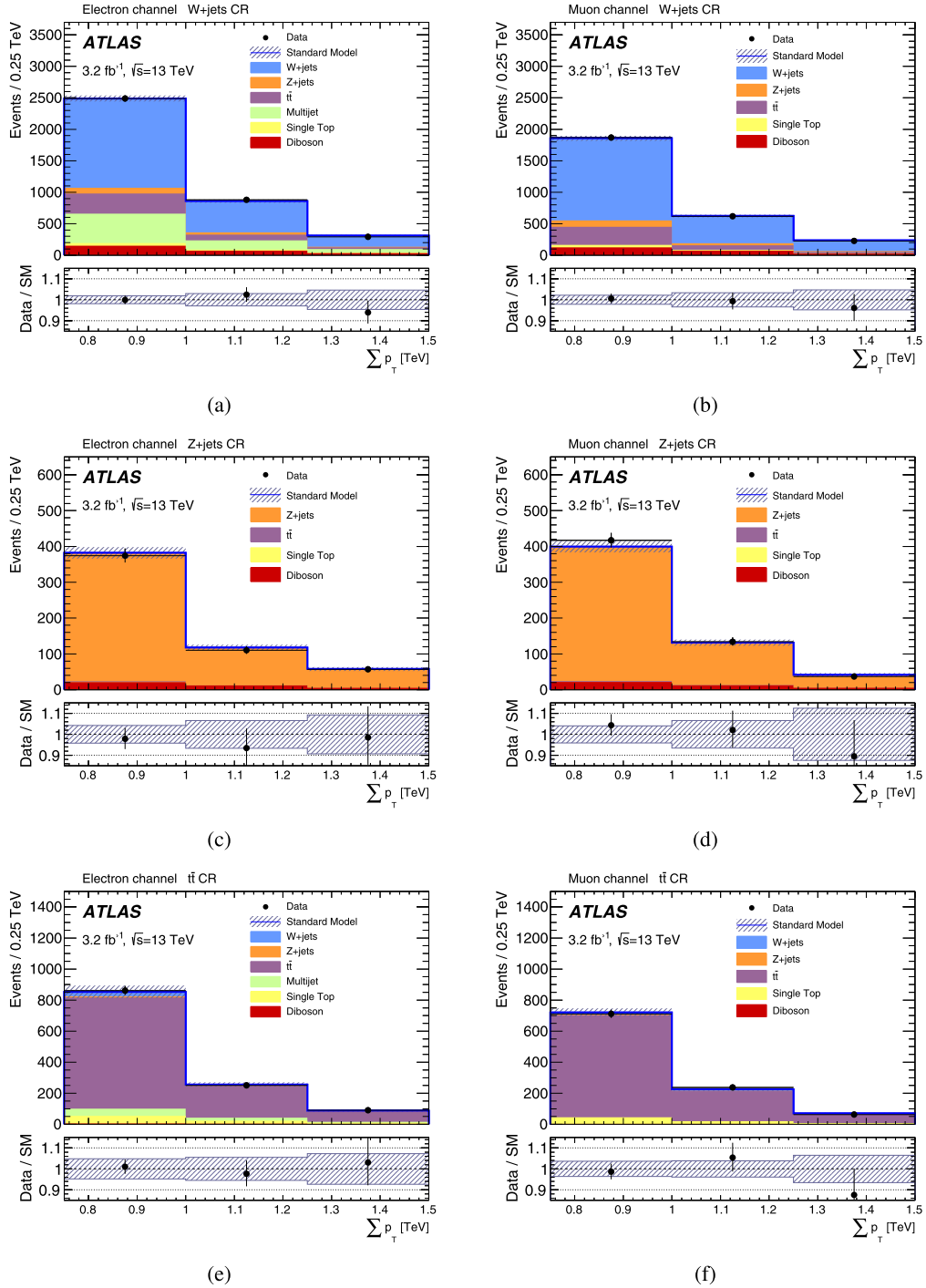


Fig. 1. The $\sum p_T$ distribution in each of the control regions. The $W + \text{jets}$ CR is shown in (a) and (b), the $Z + \text{jets}$ CR in (c) and (d), and the $t\bar{t}$ CR in (e) and (f). The electron channel is shown in (a), (c) and (e), and the muon channel in (b), (d) and (f). The data are shown as points with error bars; all expected backgrounds are shown as stacked coloured histograms, with the total background uncertainty shown as a shaded band. The lower panels show the ratio of the data to the expected background. The $t\bar{t}$, $W + \text{jets}$ and $Z + \text{jets}$ backgrounds are normalised by the factors 0.95, 0.81 and 1.01 as obtained from the background likelihood fit. The single-top-quark and diboson background normalisations are taken from the simulation. The multijet background is obtained using a data-driven method. Additionally, the likelihood fit may constrain nuisance parameters for certain systematic uncertainties, altering the normalisation and shape of some of the distributions.

section \times acceptance \times efficiency) allowed for any form of new physics in the $\text{SR-}2\text{TeV}$ ($\text{SR-}3\text{TeV}$) region which produces a lepton in conjunction with at least two other objects, each with $p_T > 100$ GeV.

Fits including predicted signal yields in all control and signal regions simultaneously are used to extract exclusion limits for specific black-hole signal models. Since the signal regions overlap in $\sum p_T$, these exclusion fits are performed for $\sum p_T > 3$ TeV, com-

binning the electron and muon data. Confidence levels are evaluated using the CL_s procedure [45]. The results are shown in Fig. 3, together with the corresponding limit from the Run 1 analysis at $\sqrt{s} = 8$ TeV [12]. The impact on the M_{th} limit for $n = 6$ due to the PDF-induced uncertainties in the signal cross-section varies from ± 200 GeV to ± 100 GeV as M_D varies from 2 TeV to 5 TeV. The limit on M_{th} is more stringent than that from the Run 1 search by almost 3 TeV at $M_D = 2$ TeV and by more than 2 TeV at

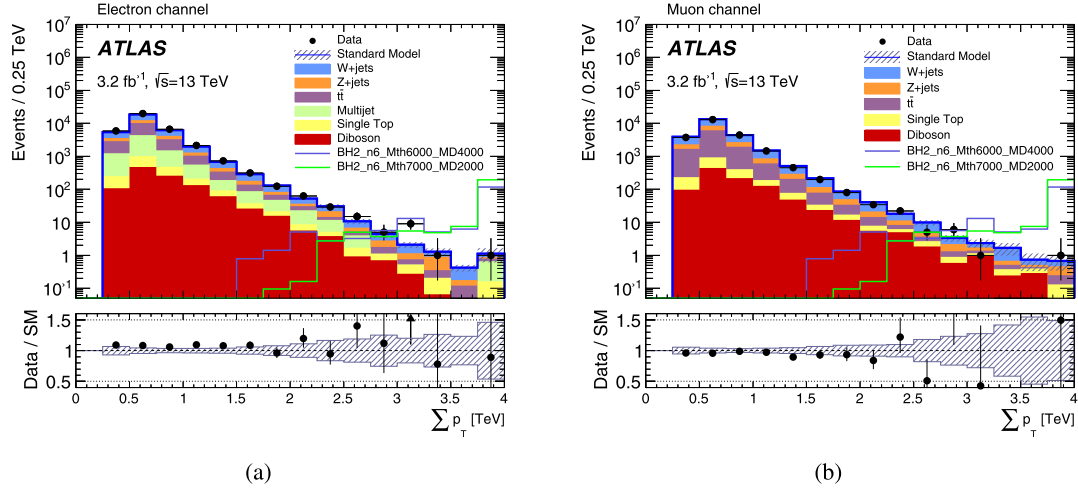


Fig. 2. The $\sum p_T$ distributions in (a) the electron channel and (b) the muon channel. The selection is that of the signal regions except for the final requirement on $\sum p_T$. The data are shown as points with error bars; all expected backgrounds are shown as stacked coloured histograms, with the total background uncertainty shown as a shaded band. Two representative signal distributions for rotating black holes with $n=6$ are overlaid to illustrate the signal properties. The lower panels show the ratio of the data to the expected background. The $t\bar{t}$, W + jets and Z + jets backgrounds are normalised by the factors 0.95, 0.81 and 1.01 as obtained from the background likelihood fit. The single-top-quark and diboson background normalisations are taken from the simulation. The multijet background is obtained using a data-driven method. Additionally, the likelihood fit may constrain nuisance parameters for certain systematic uncertainties, altering the normalisation and shape of some of the distributions.

Table 2
Background fit results for regions SR-2TeV ($\sum p_T > 2$ TeV) and SR-3TeV ($\sum p_T > 3$ TeV) for the electron and muons channels. The errors shown are the statistical plus systematic uncertainties. The uncertainty in the total background count includes correlations between nuisance parameters and so does not reflect a quadrature sum of the uncertainties in the individual background components.

	SR-2TeV (electron)	SR-2TeV (muon)	SR-3TeV (electron)	SR-3TeV (muon)
Observed events	123	69	11	2
Expected bkg events	104 ± 9	78 ± 6	4.6 ± 0.8	5.3 ± 1.2
Expected $t\bar{t}$ events	13.8 ± 3.1	11.4 ± 2.5	0.65 ± 0.18	0.55 ± 0.15
Expected W + jets events	32.0 ± 3.5	33.9 ± 3.2	1.76 ± 0.31	2.0 ± 0.4
Expected Z + jets events	16.6 ± 1.5	12.6 ± 1.4	1.09 ± 0.18	0.77 ± 0.24
Exp. single-top-quark events	6.1 ± 0.9	5.2 ± 0.7	0.59 ± 0.18	0.54 ± 0.14
Expected diboson events	11.4 ± 1.4	14.5 ± 1.5	0.22 ± 0.18	1.5 ± 0.5
Expected multijet events	24 ± 7	0.0 ± 0.0	0.32 ± 0.24	0.0 ± 0.0

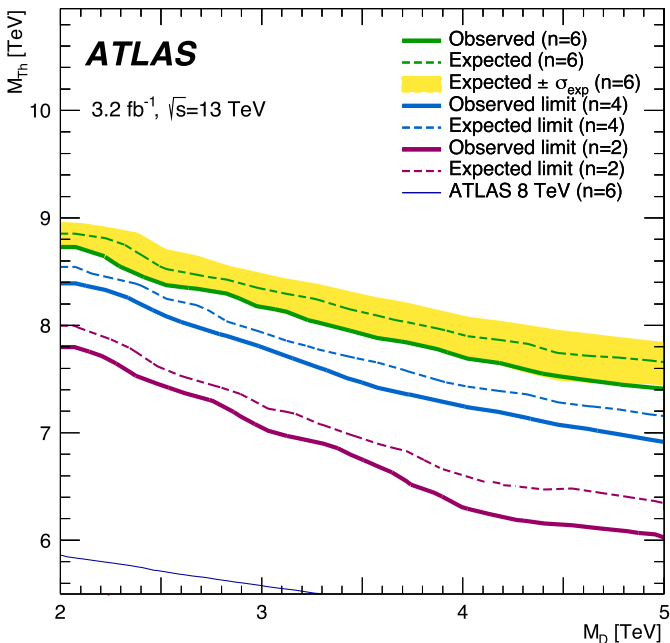


Fig. 3. Exclusion contours in the M_{th} , M_D plane for models of rotating black holes with two, four and six extra dimensions simulated with CHARYBDIS2 1.0.4. The solid (dashed) lines show the observed (expected) 95% CL lower limits, with the yellow (shaded) region illustrating the $\pm 1\sigma$ variation of the expected limit for six extra dimensions. The line at the extreme lower left shows the limit set by the analysis at 8 TeV [12] for six extra dimensions. Masses below the corresponding lines are excluded. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

$M_D = 4$ TeV. For a model of rotating black holes with two extra dimensions, the 95% CL lower limit on the threshold mass M_{th} is set at 7.8 TeV for $M_D = 2$ TeV. For a model with six extra dimensions, the limit is set at 7.4 TeV for $M_D = 5$ TeV.

5. Conclusion

A search has been performed for signatures of TeV-scale gravity in high-mass final states including at least one lepton in conjunction with at least two other leptons or hadronic jets each with $p_T > 100$ GeV, using 3.2 fb^{-1} of proton–proton collisions recorded by the ATLAS detector at the LHC at a centre-of-mass energy of 13 TeV. No significant deviation from the background predictions is observed. Upper limits are therefore set on the possible contribution of new physics processes in this class of final states at 12.1 fb (3.4 fb) at 95% CL for $\sum p_T > 2$ TeV (3 TeV). Constraints are placed on production of microscopic black holes in models with two to six extra space dimensions which substantially extend the excluded range of model parameters. The results of this analysis could potentially be used to constrain other models predicting new phenomena at the TeV scale involving decays to leptons and jets.

Acknowledgements

We thank CERN for the very successful operation of the LHC, as well as the support staff from our institutions without whom ATLAS could not be operated efficiently.

We acknowledge the support of ANPCyT, Argentina; YerPhI, Armenia; ARC, Australia; BMWFW and FWF, Austria; ANAS, Azerbaijan; SSTC, Belarus; CNPq and FAPESP, Brazil; NSERC, NRC and CFI, Canada; CERN; CONICYT, Chile; CAS, MOST and NSFC, China; COLCIENCIAS, Colombia; MSMT CR, MPO CR and VSC CR, Czech Republic; DNRF and DNSRC, Denmark; IN2P3-CNRS, CEA-DSM/IRFU, France; GNSF, Georgia; BMBF, HGF, and MPG, Germany; GSRT, Greece; RGC, Hong Kong SAR, China; ISF, I-CORE and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; RCN, Norway; MNiSW and NCN, Poland; FCT, Portugal; MNE/IFA, Romania; MES of Russia and NRC KI, Russian Federation; JINR; MESTD, Serbia; MSSR, Slovakia; ARRS and MIZŠ, Slovenia; DST/NRF, South Africa; MINECO, Spain; SRC and Knut and Alice Wallenberg Foundation, Sweden; SERI, SNSF and Cantons of Bern and Geneva, Switzerland; MOST, Taiwan; TAEK, Turkey; STFC, United Kingdom; DOE and NSF, United States of America. In addition, individual groups and members have received support from BCKDF, the Canada Council, Canarie, CRC, Compute Canada, FQRNT, and the Ontario Innovation Trust, Canada; EPLANET, ERC, FP7, Horizon 2020 and Marie Skłodowska-Curie Actions, European Union; Investissements d'Avenir Labex and Idex, ANR, Région Auvergne and Fondation Partager le Savoir, France; DFG and AvH Foundation, Germany; Herakleitos, Thales and Aristeia programmes co-financed by EU-ESF and the Greek NSRF; BSF, GIF and Minerva, Israel; BRF, Norway; Generalitat de Catalunya, Generalitat Valenciana, Spain; the Royal Society and Leverhulme Trust, United Kingdom.

The crucial computing support from all WLCG partners is acknowledged gratefully, in particular from CERN and the ATLAS Tier-1 facilities at TRIUMF (Canada), NDGF (Denmark, Norway, Sweden), CC-IN2P3 (France), KIT/GridKA (Germany), INFN-CNAF (Italy), NL-T1 (Netherlands), PIC (Spain), ASGC (Taiwan), RAL (UK) and BNL (USA) and in the Tier-2 facilities worldwide.

References

- [1] N. Arkani-Hamed, S. Dimopoulos, G. Dvali, The hierarchy problem and new dimensions at a millimeter, *Phys. Lett. B* 429 (1998) 263–272, arXiv:hep-ph/9803315.
- [2] I. Antoniadis, et al., New dimensions at a millimeter to a Fermi and superstrings at a TeV, *Phys. Lett. B* 436 (1998) 257–263, arXiv:hep-ph/9804398.
- [3] L. Randall, R. Sundrum, A large mass hierarchy from a small extra dimension, *Phys. Rev. Lett.* 83 (1999) 3370–3373, arXiv:hep-ph/9905221.
- [4] L. Randall, R. Sundrum, An alternative to compactification, *Phys. Rev. Lett.* 83 (1999) 4690–4693, arXiv:hep-th/9906064.
- [5] S. Dimopoulos, G.L. Landsberg, Black holes at the LHC, *Phys. Rev. Lett.* 87 (2001) 161602, arXiv:hep-ph/0106295.
- [6] S.B. Giddings, S.D. Thomas, High-energy colliders as black hole factories: the end of short distance physics, *Phys. Rev. D* 65 (2002) 056010, arXiv:hep-ph/0106219.
- [7] L. Evans, P. Bryant, LHC machine, in: L. Evans (Ed.), *J. Instrum.* 3 (2008) S08001.
- [8] S. Hawking, Particle creation by black holes, *Commun. Math. Phys.* 43 (1975) 199.
- [9] ATLAS Collaboration, Search for strong gravity signatures in same-sign dimuon final states using the ATLAS detector at the LHC, *Phys. Lett. B* 709 (2012) 322, arXiv:1111.0080 [hep-ex].
- [10] ATLAS Collaboration, Search for TeV-scale gravity signatures in final states with leptons and jets with the ATLAS detector at $\sqrt{s} = 7$ TeV, *Phys. Lett. B* 716 (2012) 122–141, arXiv:1204.4646 [hep-ex].
- [11] ATLAS Collaboration, Search for microscopic black holes in a like-sign dimuon final state using large track multiplicity with the ATLAS detector, *Phys. Rev. D* 88 (2013) 072001, arXiv:1308.4075 [hep-ex].
- [12] ATLAS Collaboration, Search for microscopic black holes and string balls in final states with leptons and jets with the ATLAS detector at $\sqrt{s} = 8$ TeV, *J. High Energy Phys.* 1408 (2014) 103, arXiv:1405.4254 [hep-ex].
- [13] CMS Collaboration, Search for microscopic black hole signatures at the Large Hadron Collider, *Phys. Lett. B* 697 (2011) 434, arXiv:1012.3375 [hep-ex].
- [14] CMS Collaboration, Search for microscopic black holes in pp collisions at $\sqrt{s} = 8$ TeV, *J. High Energy Phys.* 1307 (2013) 178, arXiv:1303.5338 [hep-ex].
- [15] ATLAS Collaboration, Search for strong gravity in multijet final states produced in pp collisions at $\sqrt{s} = 13$ TeV using the ATLAS detector at the LHC, *J. High Energy Phys.* 1603 (2016) 026, arXiv:1512.02586 [hep-ex].
- [16] ATLAS Collaboration, The ATLAS experiment at the CERN Large Hadron Collider, *J. Instrum.* 3 (2008) S08003.
- [17] ATLAS Collaboration, ATLAS insertable B-layer technical design report, <http://cds.cern.ch/record/1291633>, 2010.
- [18] ATLAS Collaboration, 2015 start-up trigger menu and initial performance assessment of the ATLAS trigger using Run-2 data, tech. rep. ATL-DAQ-PUB-2016-001, CERN, 2016, <http://cds.cern.ch/record/2136007>.
- [19] J.A. Frost, et al., Phenomenology of production and decay of spinning extra-dimensional black holes at hadron colliders, *J. High Energy Phys.* 0910 (2009) 014, arXiv:0904.0979 [hep-ph].
- [20] J. Pumplin, et al., New generation of parton distributions with uncertainties from global QCD analysis, *J. High Energy Phys.* 0207 (2002) 012, arXiv:hep-ph/0201195.
- [21] T. Sjöstrand, S. Mrenna, P.Z. Skands, A brief introduction to PYTHIA 8.1, *Comput. Phys. Commun.* 178 (2008) 852–867, arXiv:0710.3820 [hep-ph].
- [22] ATLAS Collaboration, The ATLAS simulation infrastructure, *Eur. Phys. J. C* 70 (2010) 823–874, arXiv:1005.4568 [physics.ins-det].
- [23] S. Agostinelli, et al., GEANT4: a simulation toolkit, *Nucl. Instrum. Methods Phys. Res., Sect. A, Accel. Spectrom. Detect. Assoc. Equip.* 506 (2003) 250–303.
- [24] ATLAS Collaboration, Improved luminosity determination in pp collisions at $\sqrt{s} = 7$ TeV using the ATLAS detector at the LHC, *Eur. Phys. J. C* 73 (2013) 2518, arXiv:1302.4393 [hep-ex].
- [25] ATLAS Collaboration, Electron identification measurements in ATLAS using $\sqrt{s} = 13$ TeV data with 50 ns bunch spacing, tech. rep. ATL-PHYS-PUB-2015-041, CERN, 2015, <http://cds.cern.ch/record/2048202>.
- [26] ATLAS Collaboration, Muon reconstruction performance of the ATLAS detector in proton–proton collision data at $\sqrt{s} = 13$ TeV, arXiv:1603.05598 [hep-ex], 2016.
- [27] M. Cacciari, G.P. Salam, G. Soyez, The anti- $k(t)$ jet clustering algorithm, *J. High Energy Phys.* 0804 (2008) 063, arXiv:0802.1189 [hep-ph].
- [28] ATLAS Collaboration, Selection of jets produced in 13 TeV proton–proton collisions with the ATLAS detector, <http://cds.cern.ch/record/2037702>, 2015.
- [29] ATLAS Collaboration, Jet calibration and systematic uncertainties for jets reconstructed in the ATLAS detector at $\sqrt{s} = 13$ TeV, <http://cds.cern.ch/record/2037613>, 2015.
- [30] ATLAS Collaboration, Expected performance of the ATLAS b -tagging algorithms in Run-2, tech. rep. ATL-PHYS-PUB-2015-022, CERN, 2015, <http://cds.cern.ch/record/2037697>.
- [31] ATLAS Collaboration, Commissioning of the ATLAS b -tagging algorithms using $t\bar{t}$ events in early Run-2 data, tech. rep. ATL-PHYS-PUB-2015-039, CERN, 2015, <http://cds.cern.ch/record/2047871>.
- [32] ATLAS Collaboration, Performance of pile-up mitigation techniques for jets in pp collisions at $\sqrt{s} = 8$ TeV using the ATLAS detector, arXiv:1510.03823 [hep-ex], 2015.
- [33] ATLAS Collaboration, Electron efficiency measurements with the ATLAS detector using the 2012 LHC proton–proton collision data, <http://cds.cern.ch/record/1706245>, 2014.
- [34] M. Aliev, et al., HATHOR: hadronic top and heavy quark cross section calculator, *Comput. Phys. Commun.* 182 (2011) 1034, arXiv:1007.1327 [hep-ph].
- [35] P. Kant, et al., HatHor for single top-quark production: updated predictions and uncertainty estimates for single top-quark production in hadronic collisions, *Comput. Phys. Commun.* 191 (2015) 74–89, arXiv:1406.4403 [hep-ph].
- [36] T. Gleisberg, et al., Event generation with SHERPA 1.1, *J. High Energy Phys.* 0902 (2009) 007, arXiv:0811.4622 [hep-ph].
- [37] P. Nason, A new method for combining NLO QCD with shower Monte Carlo algorithms, *J. High Energy Phys.* 0411 (2004) 040, arXiv:hep-ph/0409146.
- [38] S. Frixione, P. Nason, C. Oleari, Matching NLO QCD computations with parton shower simulations: the POWHEG method, *J. High Energy Phys.* 0711 (2007) 070, arXiv:0709.2092 [hep-ph].
- [39] S. Alioli, et al., A general framework for implementing NLO calculations in shower Monte Carlo programs: the POWHEG BOX, *J. High Energy Phys.* 1006 (2010) 043, arXiv:1002.2581 [hep-ph].
- [40] T. Sjöstrand, S. Mrenna, P.Z. Skands, PYTHIA 6.4 physics and manual, *J. High Energy Phys.* 0605 (2006) 026, arXiv:hep-ph/0603175.
- [41] H.-L. Lai, et al., New parton distributions for collider physics, *Phys. Rev. D* 82 (2010) 074024, arXiv:1007.2241 [hep-ph].
- [42] ATLAS Collaboration, Measurement of the top quark-pair production cross section with ATLAS in pp collisions at $\sqrt{s} = 7$ TeV, *Eur. Phys. J. C* 71 (2011) 1577, arXiv:1012.1792 [hep-ex].
- [43] ATLAS Collaboration, Expected performance of missing transverse momentum reconstruction for the ATLAS detector at $\sqrt{s} = 13$ TeV, tech. rep. ATL-PHYS-PUB-2015-023, CERN, 2015, <http://cds.cern.ch/record/2037700>.

[44] S. Catani, et al., QCD matrix elements + parton showers, *J. High Energy Phys.* 0111 (2001) 063, arXiv:hep-ph/0109231.

[45] A.L. Read, Presentation of search results: the CL_s technique, *J. Phys. G* 28 (2002) 2693, <http://stacks.iop.org/0954-3899/28/i=10/a=313>.

The ATLAS Collaboration

M. Aaboud^{135d}, G. Aad⁸⁶, B. Abbott¹¹³, J. Abdallah⁶⁴, O. Abdinov¹², B. Abeloos¹¹⁷, R. Aben¹⁰⁷, O.S. AbouZeid¹³⁷, N.L. Abraham¹⁴⁹, H. Abramowicz¹⁵³, H. Abreu¹⁵², R. Abreu¹¹⁶, Y. Abulaiti^{146a,146b}, B.S. Acharya^{163a,163b,a}, L. Adamczyk^{40a}, D.L. Adams²⁷, J. Adelman¹⁰⁸, S. Adomeit¹⁰⁰, T. Adye¹³¹, A.A. Affolder⁷⁵, T. Agatonovic-Jovin¹⁴, J. Agricola⁵⁶, J.A. Aguilar-Saavedra^{126a,126f}, S.P. Ahlen²⁴, F. Ahmadov^{66,b}, G. Aielli^{133a,133b}, H. Akerstedt^{146a,146b}, T.P.A. Åkesson⁸², A.V. Akimov⁹⁶, G.L. Alberghi^{22a,22b}, J. Albert¹⁶⁸, S. Albrand⁵⁷, M.J. Alconada Verzini⁷², M. Aleksa³², I.N. Aleksandrov⁶⁶, C. Alexa^{28b}, G. Alexander¹⁵³, T. Alexopoulos¹⁰, M. Alhroob¹¹³, B. Ali¹²⁸, M. Aliev^{74a,74b}, G. Alimonti^{92a}, J. Alison³³, S.P. Alkire³⁷, B.M.M. Allbrooke¹⁴⁹, B.W. Allen¹¹⁶, P.P. Allport¹⁹, A. Aloisio^{104a,104b}, A. Alonso³⁸, F. Alonso⁷², C. Alpigiani¹³⁸, M. Alstamy⁸⁶, B. Alvarez Gonzalez³², D. Álvarez Piqueras¹⁶⁶, M.G. Alviggi^{104a,104b}, B.T. Amadio¹⁶, K. Amako⁶⁷, Y. Amaral Coutinho^{26a}, C. Amelung²⁵, D. Amidei⁹⁰, S.P. Amor Dos Santos^{126a,126c}, A. Amorim^{126a,126b}, S. Amoroso³², G. Amundsen²⁵, C. Anastopoulos¹³⁹, L.S. Ancu⁵¹, N. Andari¹⁰⁸, T. Andeen¹¹, C.F. Anders^{59b}, G. Anders³², J.K. Anders⁷⁵, K.J. Anderson³³, A. Andreazza^{92a,92b}, V. Andrei^{59a}, S. Angelidakis⁹, I. Angelozzi¹⁰⁷, P. Anger⁴⁶, A. Angerami³⁷, F. Anghinolfi³², A.V. Anisenkov^{109,c}, N. Anjos¹³, A. Annovi^{124a,124b}, C. Antel^{59a}, M. Antonelli⁴⁹, A. Antonov⁹⁸, F. Anulli^{132a}, M. Aoki⁶⁷, L. Aperio Bella¹⁹, G. Arabidze⁹¹, Y. Arai⁶⁷, J.P. Araque^{126a}, A.T.H. Arce⁴⁷, F.A. Arduh⁷², J-F. Arguin⁹⁵, S. Argyropoulos⁶⁴, M. Arik^{20a}, A.J. Armbruster¹⁴³, L.J. Armitage⁷⁷, O. Arnaez³², H. Arnold⁵⁰, M. Arratia³⁰, O. Arslan²³, A. Artamonov⁹⁷, G. Artoni¹²⁰, S. Artz⁸⁴, S. Asai¹⁵⁵, N. Asbah⁴⁴, A. Ashkenazi¹⁵³, B. Åsman^{146a,146b}, L. Asquith¹⁴⁹, K. Assamagan²⁷, R. Astalos^{144a}, M. Atkinson¹⁶⁵, N.B. Atlay¹⁴¹, K. Augsten¹²⁸, G. Avolio³², B. Axen¹⁶, M.K. Ayoub¹¹⁷, G. Azuelos^{95,d}, M.A. Baak³², A.E. Baas^{59a}, M.J. Baca¹⁹, H. Bachacou¹³⁶, K. Bachas^{74a,74b}, M. Backes³², M. Backhaus³², P. Bagiachi^{132a,132b}, P. Bagnaia^{132a,132b}, Y. Bai^{35a}, J.T. Baines¹³¹, O.K. Baker¹⁷⁵, E.M. Baldin^{109,c}, P. Balek¹⁷¹, T. Balestri¹⁴⁸, F. Balli¹³⁶, W.K. Balunas¹²², E. Banas⁴¹, Sw. Banerjee^{172,e}, A.A.E. Bannoura¹⁷⁴, L. Barak³², E.L. Barberio⁸⁹, D. Barberis^{52a,52b}, M. Barbero⁸⁶, T. Barillari¹⁰¹, M-S Barisits³², T. Barklow¹⁴³, N. Barlow³⁰, S.L. Barnes⁸⁵, B.M. Barnett¹³¹, R.M. Barnett¹⁶, Z. Barnovska⁵, A. Baroncelli^{134a}, G. Barone²⁵, A.J. Barr¹²⁰, L. Barranco Navarro¹⁶⁶, F. Barreiro⁸³, J. Barreiro Guimarães da Costa^{35a}, R. Bartoldus¹⁴³, A.E. Barton⁷³, P. Bartos^{144a}, A. Basalae¹²³, A. Bassalat¹¹⁷, R.L. Bates⁵⁵, S.J. Batista¹⁵⁸, J.R. Batley³⁰, M. Battaglia¹³⁷, M. Baue^{132a,132b}, F. Bauer¹³⁶, H.S. Bawa^{143,f}, J.B. Beacham¹¹¹, M.D. Beattie⁷³, T. Beau⁸¹, P.H. Beauchemin¹⁶¹, P. Bechtel²³, H.P. Beck^{18,g}, K. Becker¹²⁰, M. Becker⁸⁴, M. Beckingham¹⁶⁹, C. Becot¹¹⁰, A.J. Beddall^{20e}, A. Beddall^{20b}, V.A. Bednyakov⁶⁶, M. Bedognetti¹⁰⁷, C.P. Bee¹⁴⁸, L.J. Beemster¹⁰⁷, T.A. Beermann³², M. Begel²⁷, J.K. Behr⁴⁴, C. Belanger-Champagne⁸⁸, A.S. Bell⁷⁹, G. Bella¹⁵³, L. Bellagamba^{22a}, A. Bellerive³¹, M. Bellomo⁸⁷, K. Belotskiy⁹⁸, O. Beltramello³², N.L. Belyaev⁹⁸, O. Benary¹⁵³, D. Benchekroun^{135a}, M. Bender¹⁰⁰, K. Bendtz^{146a,146b}, N. Benekos¹⁰, Y. Benhammou¹⁵³, E. Benhar Noccioli¹⁷⁵, J. Benitez⁶⁴, D.P. Benjamin⁴⁷, J.R. Bensinger²⁵, S. Bentvelsen¹⁰⁷, L. Beresford¹²⁰, M. Beretta⁴⁹, D. Berge¹⁰⁷, E. Bergeas Kuutmann¹⁶⁴, N. Berger⁵, J. Beringer¹⁶, S. Berlendis⁵⁷, N.R. Bernard⁸⁷, C. Bernius¹¹⁰, F.U. Bernlochner²³, T. Berry⁷⁸, P. Berta¹²⁹, C. Bertella⁸⁴, G. Bertoli^{146a,146b}, F. Bertolucci^{124a,124b}, I.A. Bertram⁷³, C. Bertsche⁴⁴, D. Bertsche¹¹³, G.J. Besjes³⁸, O. Bessidskaia Bylund^{146a,146b}, M. Bessner⁴⁴, N. Besson¹³⁶, C. Betancourt⁵⁰, S. Bethke¹⁰¹, A.J. Bevan⁷⁷, R.M. Bianchi¹²⁵, L. Bianchini²⁵, M. Bianco³², O. Biebel¹⁰⁰, D. Biedermann¹⁷, R. Bielski⁸⁵, N.V. Biesuz^{124a,124b}, M. Biglietti^{134a}, J. Bilbao De Mendizabal⁵¹, T.R.V. Billoud⁹⁵, H. Bilokon⁴⁹, M. Bindi⁵⁶, S. Binet¹¹⁷, A. Bingul^{20b}, C. Bini^{132a,132b}, S. Biondi^{22a,22b}, D.M. Bjergaard⁴⁷, C.W. Black¹⁵⁰, J.E. Black¹⁴³, K.M. Black²⁴, D. Blackburn¹³⁸, R.E. Blair⁶, J.-B. Blanchard¹³⁶, J.E. Blanco⁷⁸, T. Blazek^{144a}, I. Bloch⁴⁴, C. Blocker²⁵, W. Blum^{84,*}, U. Blumenschein⁵⁶, S. Blunier^{34a}, G.J. Bobbink¹⁰⁷, V.S. Bobrovnikov^{109,c}, S.S. Bocchetta⁸², A. Bocci⁴⁷, C. Bock¹⁰⁰, M. Boehler⁵⁰, D. Boerner¹⁷⁴, J.A. Bogaerts³², D. Bogavac¹⁴, A.G. Bogdanchikov¹⁰⁹, C. Bohm^{146a}, V. Boisvert⁷⁸, P. Bokan¹⁴, T. Bold^{40a}, A.S. Boldyrev^{163a,163c}, M. Bomben⁸¹, M. Bona⁷⁷, M. Boonekamp¹³⁶, A. Borisov¹³⁰, G. Borissov⁷³, J. Bortfeldt³², D. Bortoletto¹²⁰, V. Bortolotto^{61a,61b,61c}, K. Bos¹⁰⁷, D. Boscherini^{22a}, M. Bosman¹³, J.D. Bossio Sola²⁹, J. Boudreau¹²⁵, J. Bouffard², E.V. Bouhova-Thacker⁷³, D. Boumediene³⁶, C. Bourdarios¹¹⁷, S.K. Boutle⁵⁵,

A. Boveia³², J. Boyd³², I.R. Boyko⁶⁶, J. Bracinik¹⁹, A. Brandt⁸, G. Brandt⁵⁶, O. Brandt^{59a}, U. Bratzler¹⁵⁶, B. Brau⁸⁷, J.E. Brau¹¹⁶, H.M. Braun^{174,*}, W.D. Breaden Madden⁵⁵, K. Brendlinger¹²², A.J. Brennan⁸⁹, L. Brenner¹⁰⁷, R. Brenner¹⁶⁴, S. Bressler¹⁷¹, T.M. Bristow⁴⁸, D. Britton⁵⁵, D. Britzger⁴⁴, F.M. Brochu³⁰, I. Brock²³, R. Brock⁹¹, G. Brooijmans³⁷, T. Brooks⁷⁸, W.K. Brooks^{34b}, J. Brosamer¹⁶, E. Brost¹¹⁶, J.H. Broughton¹⁹, P.A. Bruckman de Renstrom⁴¹, D. Bruncko^{144b}, R. Bruneliere⁵⁰, A. Bruni^{22a}, G. Bruni^{22a}, L.S. Bruni¹⁰⁷, B.H. Brunt³⁰, M. Bruschi^{22a}, N. Bruscino²³, P. Bryant³³, L. Bryngemark⁸², T. Buanes¹⁵, Q. Buat¹⁴², P. Buchholz¹⁴¹, A.G. Buckley⁵⁵, I.A. Budagov⁶⁶, F. Buehrer⁵⁰, M.K. Bugge¹¹⁹, O. Bulekov⁹⁸, D. Bullock⁸, H. Burckhart³², S. Burdin⁷⁵, C.D. Burgard⁵⁰, B. Burghgrave¹⁰⁸, K. Burka⁴¹, S. Burke¹³¹, I. Burmeister⁴⁵, J.T.P. Burr¹²⁰, E. Busato³⁶, D. Büscher⁵⁰, V. Büscher⁸⁴, P. Bussey⁵⁵, J.M. Butler²⁴, C.M. Buttar⁵⁵, J.M. Butterworth⁷⁹, P. Butti¹⁰⁷, W. Buttinger²⁷, A. Buzatu⁵⁵, A.R. Buzykaev^{109,c}, S. Cabrera Urbán¹⁶⁶, D. Caforio¹²⁸, V.M. Cairo^{39a,39b}, O. Cakir^{4a}, N. Calace⁵¹, P. Calafiura¹⁶, A. Calandri⁸⁶, G. Calderini⁸¹, P. Calfayan¹⁰⁰, G. Callea^{39a,39b}, L.P. Caloba^{26a}, S. Calvente Lopez⁸³, D. Calvet³⁶, S. Calvet³⁶, T.P. Calvet⁸⁶, R. Camacho Toro³³, S. Camarda³², P. Camarri^{133a,133b}, D. Cameron¹¹⁹, R. Caminal Armadans¹⁶⁵, C. Camincher⁵⁷, S. Campana³², M. Campanelli⁷⁹, A. Camplani^{92a,92b}, A. Campoverde¹⁴¹, V. Canale^{104a,104b}, A. Canepa^{159a}, M. Cano Bret^{35e}, J. Cantero¹¹⁴, R. Cantrill^{126a}, T. Cao⁴², M.D.M. Capeans Garrido³², I. Caprini^{28b}, M. Caprini^{28b}, M. Capua^{39a,39b}, R. Caputo⁸⁴, R.M. Carbone³⁷, R. Cardarelli^{133a}, F. Cardillo⁵⁰, I. Carli¹²⁹, T. Carli³², G. Carlino^{104a}, L. Carminati^{92a,92b}, S. Caron¹⁰⁶, E. Carquin^{34b}, G.D. Carrillo-Montoya³², J.R. Carter³⁰, J. Carvalho^{126a,126c}, D. Casadei¹⁹, M.P. Casado^{13,h}, M. Casolino¹³, D.W. Casper¹⁶², E. Castaneda-Miranda^{145a}, R. Castelijns¹⁰⁷, A. Castelli¹⁰⁷, V. Castillo Gimenez¹⁶⁶, N.F. Castro^{126a,i}, A. Catinaccio³², J.R. Catmore¹¹⁹, A. Cattai³², J. Caudron⁸⁴, V. Cavaliere¹⁶⁵, E. Cavallaro¹³, D. Cavalli^{92a}, M. Cavalli-Sforza¹³, V. Cavasinni^{124a,124b}, F. Ceradini^{134a,134b}, L. Cerda Alberich¹⁶⁶, B.C. Cerio⁴⁷, A.S. Cerqueira^{26b}, A. Cerri¹⁴⁹, L. Cerrito⁷⁷, F. Cerutti¹⁶, M. Cerv³², A. Cervelli¹⁸, S.A. Cetin^{20d}, A. Chafaq^{135a}, D. Chakraborty¹⁰⁸, S.K. Chan⁵⁸, Y.L. Chan^{61a}, P. Chang¹⁶⁵, J.D. Chapman³⁰, D.G. Charlton¹⁹, A. Chatterjee⁵¹, C.C. Chau¹⁵⁸, C.A. Chavez Barajas¹⁴⁹, S. Che¹¹¹, S. Cheatham⁷³, A. Chegwidan⁹¹, S. Chekanov⁶, S.V. Chekulaev^{159a}, G.A. Chelkov^{66,j}, M.A. Chelstowska⁹⁰, C. Chen⁶⁵, H. Chen²⁷, K. Chen¹⁴⁸, S. Chen^{35c}, S. Chen¹⁵⁵, X. Chen^{35f}, Y. Chen⁶⁸, H.C. Cheng⁹⁰, H.J. Cheng^{35a}, Y. Cheng³³, A. Cheplakov⁶⁶, E. Cheremushkina¹³⁰, R. Cherkaoui El Moursli^{135e}, V. Chernyatin^{27,*}, E. Cheu⁷, L. Chevalier¹³⁶, V. Chiarella⁴⁹, G. Chiarelli^{124a,124b}, G. Chiodini^{74a}, A.S. Chisholm¹⁹, A. Chitan^{28b}, M.V. Chizhov⁶⁶, K. Choi⁶², A.R. Chomont³⁶, S. Chouridou⁹, B.K.B. Chow¹⁰⁰, V. Christodoulou⁷⁹, D. Chromek-Burckhart³², J. Chudoba¹²⁷, A.J. Chuinard⁸⁸, J.J. Chwastowski⁴¹, L. Chytka¹¹⁵, G. Ciapetti^{132a,132b}, A.K. Ciftci^{4a}, D. Cinca⁴⁵, V. Cindro⁷⁶, I.A. Cioara²³, C. Ciocca^{22a,22b}, A. Ciocio¹⁶, F. Ciotto^{104a,104b}, Z.H. Citron¹⁷¹, M. Citterio^{92a}, M. Ciubancan^{28b}, A. Clark⁵¹, B.L. Clark⁵⁸, M.R. Clark³⁷, P.J. Clark⁴⁸, R.N. Clarke¹⁶, C. Clement^{146a,146b}, Y. Coadou⁸⁶, M. Cobal^{163a,163c}, A. Coccaro⁵¹, J. Cochran⁶⁵, L. Coffey²⁵, L. Colasurdo¹⁰⁶, B. Cole³⁷, A.P. Colijn¹⁰⁷, J. Collot⁵⁷, T. Colombo³², G. Compostella¹⁰¹, P. Conde Muiño^{126a,126b}, E. Coniavitis⁵⁰, S.H. Connell^{145b}, I.A. Connelly⁷⁸, V. Consorti⁵⁰, S. Constantinescu^{28b}, G. Conti³², F. Conventi^{104a,k}, M. Cooke¹⁶, B.D. Cooper⁷⁹, A.M. Cooper-Sarkar¹²⁰, K.J.R. Cormier¹⁵⁸, T. Cornelissen¹⁷⁴, M. Corradi^{132a,132b}, F. Corriveau^{88,l}, A. Corso-Radu¹⁶², A. Cortes-Gonzalez¹³, G. Cortiana¹⁰¹, G. Costa^{92a}, M.J. Costa¹⁶⁶, D. Costanzo¹³⁹, G. Cottin³⁰, G. Cowan⁷⁸, B.E. Cox⁸⁵, K. Cranmer¹¹⁰, S.J. Crawley⁵⁵, G. Cree³¹, S. Crépe-Renaudin⁵⁷, F. Crescioli⁸¹, W.A. Cribbs^{146a,146b}, M. Crispin Ortuzar¹²⁰, M. Cristinziani²³, V. Croft¹⁰⁶, G. Crosetti^{39a,39b}, A. Cueto⁸³, T. Cuhadar Donszelmann¹³⁹, J. Cummings¹⁷⁵, M. Curatolo⁴⁹, J. Cúth⁸⁴, C. Cuthbert¹⁵⁰, H. Czirr¹⁴¹, P. Czodrowski³, G. D'amen^{22a,22b}, S. D'Auria⁵⁵, M. D'Onofrio⁷⁵, M.J. Da Cunha Sargedass De Sousa^{126a,126b}, C. Da Via⁸⁵, W. Dabrowski^{40a}, T. Dado^{144a}, T. Dai⁹⁰, O. Dale¹⁵, F. Dallaire⁹⁵, C. Dallapiccola⁸⁷, M. Dam³⁸, J.R. Dandoy³³, N.P. Dang⁵⁰, A.C. Daniells¹⁹, N.S. Dann⁸⁵, M. Danninger¹⁶⁷, M. Dano Hoffmann¹³⁶, V. Dao⁵⁰, G. Darbo^{52a}, S. Darmora⁸, J. Dassoulas³, A. Dattagupta⁶², W. Davey²³, C. David¹⁶⁸, T. Davidek¹²⁹, M. Davies¹⁵³, P. Davison⁷⁹, E. Dawe⁸⁹, I. Dawson¹³⁹, R.K. Daya-Ishmukhametova⁸⁷, K. De⁸, R. de Asmundis^{104a}, A. De Benedetti¹¹³, S. De Castro^{22a,22b}, S. De Cecco⁸¹, N. De Groot¹⁰⁶, P. de Jong¹⁰⁷, H. De la Torre⁸³, F. De Lorenzi⁶⁵, A. De Maria⁵⁶, D. De Pedis^{132a}, A. De Salvo^{132a}, U. De Sanctis¹⁴⁹, A. De Santo¹⁴⁹, J.B. De Vivie De Regie¹¹⁷, W.J. Dearnaley⁷³, R. Debbé²⁷, C. Debenedetti¹³⁷, D.V. Dedovich⁶⁶, N. Dehghanian³, I. Deigaard¹⁰⁷, M. Del Gaudio^{39a,39b}, J. Del Peso⁸³, T. Del Prete^{124a,124b}, D. Delgove¹¹⁷,

F. Deliot¹³⁶, C.M. Delitzsch⁵¹, M. Deliyergiyev⁷⁶, A. Dell'Acqua³², L. Dell'Asta²⁴, M. Dell'Orso^{124a,124b}, M. Della Pietra^{104a,k}, D. della Volpe⁵¹, M. Delmastro⁵, P.A. Delsart⁵⁷, D.A. DeMarco¹⁵⁸, S. Demers¹⁷⁵, M. Demichev⁶⁶, A. Demilly⁸¹, S.P. Denisov¹³⁰, D. Denysiuk¹³⁶, D. Derendarz⁴¹, J.E. Derkaoui^{135d}, F. Derue⁸¹, P. Dervan⁷⁵, K. Desch²³, C. Deterre⁴⁴, K. Dette⁴⁵, P.O. Deviveiros³², A. Dewhurst¹³¹, S. Dhaliwal²⁵, A. Di Ciaccio^{133a,133b}, L. Di Ciaccio⁵, W.K. Di Clemente¹²², C. Di Donato^{132a,132b}, A. Di Girolamo³², B. Di Girolamo³², B. Di Micco^{134a,134b}, R. Di Nardo³², A. Di Simone⁵⁰, R. Di Sipio¹⁵⁸, D. Di Valentino³¹, C. Diaconu⁸⁶, M. Diamond¹⁵⁸, F.A. Dias⁴⁸, M.A. Diaz^{34a}, E.B. Diehl⁹⁰, J. Dietrich¹⁷, S. Diglio⁸⁶, A. Dimitrievska¹⁴, J. Dingfelder²³, P. Dita^{28b}, S. Dita^{28b}, F. Dittus³², F. Djama⁸⁶, T. Djobava^{53b}, J.I. Djuvsland^{59a}, M.A.B. do Vale^{26c}, D. Dobos³², M. Dobre^{28b}, C. Doglioni⁸², T. Dohmae¹⁵⁵, J. Dolejsi¹²⁹, Z. Dolezal¹²⁹, B.A. Dolgoshein^{98,*}, M. Donadelli^{26d}, S. Donati^{124a,124b}, P. Dondero^{121a,121b}, J. Donini³⁶, J. Dopke¹³¹, A. Doria^{104a}, M.T. Dova⁷², A.T. Doyle⁵⁵, E. Drechsler⁵⁶, M. Dris¹⁰, Y. Du^{35d}, J. Duarte-Campderros¹⁵³, E. Duchovni¹⁷¹, G. Duckeck¹⁰⁰, O.A. Ducu^{95,m}, D. Duda¹⁰⁷, A. Dudarev³², E.M. Duffield¹⁶, L. Dufлот¹¹⁷, L. Duguid⁷⁸, M. Dührssen³², M. Dumancic¹⁷¹, M. Dunford^{59a}, H. Duran Yildiz^{4a}, M. Düren⁵⁴, A. Durglishvili^{53b}, D. Duschinger⁴⁶, B. Dutta⁴⁴, M. Dyndal⁴⁴, C. Eckardt⁴⁴, K.M. Ecker¹⁰¹, R.C. Edgar⁹⁰, N.C. Edwards⁴⁸, T. Eifert³², G. Eigen¹⁵, K. Einsweiler¹⁶, T. Ekelof¹⁶⁴, M. El Kacimi^{135c}, V. Ellajosyula⁸⁶, M. Ellert¹⁶⁴, S. Elles⁵, F. Ellinghaus¹⁷⁴, A.A. Elliot¹⁶⁸, N. Ellis³², J. Elmsheuser²⁷, M. Elsing³², D. Emelianov¹³¹, Y. Enari¹⁵⁵, O.C. Endner⁸⁴, M. Endo¹¹⁸, J.S. Ennis¹⁶⁹, J. Erdmann⁴⁵, A. Ereditato¹⁸, G. Ernis¹⁷⁴, J. Ernst², M. Ernst²⁷, S. Errede¹⁶⁵, E. Ertel⁸⁴, M. Escalier¹¹⁷, H. Esch⁴⁵, C. Escobar¹²⁵, B. Esposito⁴⁹, A.I. Etienvre¹³⁶, E. Etzion¹⁵³, H. Evans⁶², A. Ezhilov¹²³, F. Fabbri^{22a,22b}, L. Fabbri^{22a,22b}, G. Facini³³, R.M. Fakhruddinov¹³⁰, S. Falciano^{132a}, R.J. Falla⁷⁹, J. Faltova¹²⁹, Y. Fang^{35a}, M. Fanti^{92a,92b}, A. Farbin⁸, A. Farilla^{134a}, C. Farina¹²⁵, E.M. Farina^{121a,121b}, T. Farooque¹³, S. Farrell¹⁶, S.M. Farrington¹⁶⁹, P. Farthouat³², F. Fassi^{135e}, P. Fasnacht³², D. Fassouliotis⁹, M. Fauci Giannelli⁷⁸, A. Favareto^{52a,52b}, W.J. Fawcett¹²⁰, L. Fayard¹¹⁷, O.L. Fedin^{123,n}, W. Fedorko¹⁶⁷, S. Feigl¹¹⁹, L. Feligioni⁸⁶, C. Feng^{35d}, E.J. Feng³², H. Feng⁹⁰, A.B. Fenyuk¹³⁰, L. Feremenga⁸, P. Fernandez Martinez¹⁶⁶, S. Fernandez Perez¹³, J. Ferrando⁵⁵, A. Ferrari¹⁶⁴, P. Ferrari¹⁰⁷, R. Ferrari^{121a}, D.E. Ferreira de Lima^{59b}, A. Ferrer¹⁶⁶, D. Ferrere⁵¹, C. Ferretti⁹⁰, A. Ferretto Parodi^{52a,52b}, F. Fiedler⁸⁴, A. Filipčič⁷⁶, M. Filipuzzi⁴⁴, F. Filthaut¹⁰⁶, M. Fincke-Keeler¹⁶⁸, K.D. Finelli¹⁵⁰, M.C.N. Fiolhais^{126a,126c}, L. Fiorini¹⁶⁶, A. Firan⁴², A. Fischer², C. Fischer¹³, J. Fischer¹⁷⁴, W.C. Fisher⁹¹, N. Flaschel⁴⁴, I. Fleck¹⁴¹, P. Fleischmann⁹⁰, G.T. Fletcher¹³⁹, R.R.M. Fletcher¹²², T. Flick¹⁷⁴, A. Floderus⁸², L.R. Flores Castillo^{61a}, M.J. Flowerdew¹⁰¹, G.T. Forcolin⁸⁵, A. Formica¹³⁶, A. Forti⁸⁵, A.G. Foster¹⁹, D. Fournier¹¹⁷, H. Fox⁷³, S. Fracchia¹³, P. Francavilla⁸¹, M. Franchini^{22a,22b}, D. Francis³², L. Franconi¹¹⁹, M. Franklin⁵⁸, M. Frate¹⁶², M. Fraternali^{121a,121b}, D. Freeborn⁷⁹, S.M. Fressard-Batraneanu³², F. Friedrich⁴⁶, D. Froidevaux³², J.A. Frost¹²⁰, C. Fukunaga¹⁵⁶, E. Fullana Torregrosa⁸⁴, T. Fusayasu¹⁰², J. Fuster¹⁶⁶, C. Gabaldon⁵⁷, O. Gabizon¹⁷⁴, A. Gabrielli^{22a,22b}, A. Gabrielli¹⁶, G.P. Gach^{40a}, S. Gadatsch³², S. Gadomski⁵¹, G. Gagliardi^{52a,52b}, L.G. Gagnon⁹⁵, P. Gagnon⁶², C. Galea¹⁰⁶, B. Galhardo^{126a,126c}, E.J. Gallas¹²⁰, B.J. Gallop¹³¹, P. Gallus¹²⁸, G. Galster³⁸, K.K. Gan¹¹¹, J. Gao^{35b,86}, Y. Gao⁴⁸, Y.S. Gao^{143,f}, F.M. Garay Walls⁴⁸, C. García¹⁶⁶, J.E. García Navarro¹⁶⁶, M. Garcia-Sciveres¹⁶, R.W. Gardner³³, N. Garelli¹⁴³, V. Garonne¹¹⁹, A. Gascon Bravo⁴⁴, C. Gatti⁴⁹, A. Gaudiello^{52a,52b}, G. Gaudio^{121a}, B. Gaur¹⁴¹, L. Gauthier⁹⁵, I.L. Gavrilenko⁹⁶, C. Gay¹⁶⁷, G. Gaycken²³, E.N. Gazis¹⁰, Z. Gecse¹⁶⁷, C.N.P. Gee¹³¹, Ch. Geich-Gimbel²³, M. Geisen⁸⁴, M.P. Geisler^{59a}, C. Gemme^{52a}, M.H. Genest⁵⁷, C. Geng^{35b,o}, S. Gentile^{132a,132b}, C. Gentsos¹⁵⁴, S. George⁷⁸, D. Gerbaudo¹³, A. Gershon¹⁵³, S. Ghasemi¹⁴¹, H. Ghazlane^{135b}, M. Ghneimat²³, B. Giacobbe^{22a}, S. Giagu^{132a,132b}, P. Giannetti^{124a,124b}, B. Gibbard²⁷, S.M. Gibson⁷⁸, M. Gignac¹⁶⁷, M. Gilchriese¹⁶, T.P.S. Gillam³⁰, D. Gillberg³¹, G. Gilles¹⁷⁴, D.M. Gingrich^{3,d}, N. Giokaris⁹, M.P. Giordani^{163a,163c}, F.M. Giorgi^{22a}, F.M. Giorgi¹⁷, P.F. Giraud¹³⁶, P. Giromini⁵⁸, D. Giugni^{92a}, F. Giuli¹²⁰, C. Giuliani¹⁰¹, M. Giulini^{59b}, B.K. Gjeltsten¹¹⁹, S. Gkaitatzis¹⁵⁴, I. Gkialas¹⁵⁴, E.L. Gkougkousis¹¹⁷, L.K. Gladilin⁹⁹, C. Glasman⁸³, J. Glatzer³², P.C.F. Glaysheer⁴⁸, A. Glazov⁴⁴, M. Goblirsch-Kolb²⁵, J. Godlewski⁴¹, S. Goldfarb⁸⁹, T. Golling⁵¹, D. Golubkov¹³⁰, A. Gomes^{126a,126b,126d}, R. Gonçalves^{126a}, J. Goncalves Pinto Firmino Da Costa¹³⁶, G. Gonella⁵⁰, L. Gonella¹⁹, A. Gongadze⁶⁶, S. González de la Hoz¹⁶⁶, G. Gonzalez Parra¹³, S. Gonzalez-Sevilla⁵¹, L. Goossens³², P.A. Gorbounov⁹⁷, H.A. Gordon²⁷, I. Gorelov¹⁰⁵, B. Gorini³², E. Gorini^{74a,74b}, A. Gorišek⁷⁶, E. Gornicki⁴¹, A.T. Goshaw⁴⁷, C. Gössling⁴⁵, M.I. Gostkin⁶⁶, C.R. Goudet¹¹⁷, D. Goujdami^{135c}, A.G. Goussiou¹³⁸, N. Govender^{145b,p}

E. Gozani¹⁵², L. Graber⁵⁶, I. Grabowska-Bold^{40a}, P.O.J. Gradin⁵⁷, P. Grafström^{22a,22b}, J. Gramling⁵¹, E. Gramstad¹¹⁹, S. Grancagnolo¹⁷, V. Gratchev¹²³, P.M. Gravila^{28e}, H.M. Gray³², E. Graziani^{134a}, Z.D. Greenwood^{80,q}, C. Grefe²³, K. Gregersen⁷⁹, I.M. Gregor⁴⁴, P. Grenier¹⁴³, K. Grevtsov⁵, J. Griffiths⁸, A.A. Grillo¹³⁷, K. Grimm⁷³, S. Grinstein^{13,r}, Ph. Gris³⁶, J.-F. Grivaz¹¹⁷, S. Groh⁸⁴, J.P. Grohs⁴⁶, E. Gross¹⁷¹, J. Grosse-Knetter⁵⁶, G.C. Grossi⁸⁰, Z.J. GROUT¹⁴⁹, L. Guan⁹⁰, W. Guan¹⁷², J. Guenther⁶³, F. Guescini⁵¹, D. Guest¹⁶², O. Gueta¹⁵³, E. Guido^{52a,52b}, T. Guillemain⁵, S. Guindon², U. Gul⁵⁵, C. Gumpert³², J. Guo^{35e}, Y. Guo^{35b,o}, R. Gupta⁴², S. Gupta¹²⁰, G. Gustavino^{132a,132b}, P. Gutierrez¹¹³, N.G. Gutierrez Ortiz⁷⁹, C. Gutsche⁴⁶, C. Guyot¹³⁶, C. Gwenlan¹²⁰, C.B. Gwilliam⁷⁵, A. Haas¹¹⁰, C. Haber¹⁶, H.K. Hadavand⁸, N. Haddad^{135e}, A. Hadeef⁸⁶, P. Haefner²³, S. Hageböck²³, Z. Hajduk⁴¹, H. Hakobyan^{176,*}, M. Haleem⁴⁴, J. Haley¹¹⁴, G. Halladjian⁹¹, G.D. Hallewell⁸⁶, K. Hamacher¹⁷⁴, P. Hamal¹¹⁵, K. Hamano¹⁶⁸, A. Hamilton^{145a}, G.N. Hamity¹³⁹, P.G. Hamnett⁴⁴, L. Han^{35b}, K. Hanagaki^{67,s}, K. Hanawa¹⁵⁵, M. Hance¹³⁷, B. Haney¹²², S. Hanisch³², P. Hanke^{59a}, R. Hanna¹³⁶, J.B. Hansen³⁸, J.D. Hansen³⁸, M.C. Hansen²³, P.H. Hansen³⁸, K. Hara¹⁶⁰, A.S. Hard¹⁷², T. Harenberg¹⁷⁴, F. Hariri¹¹⁷, S. Harkusha⁹³, R.D. Harrington⁴⁸, P.F. Harrison¹⁶⁹, F. Hartjes¹⁰⁷, N.M. Hartmann¹⁰⁰, M. Hasegawa⁶⁸, Y. Hasegawa¹⁴⁰, A. Hasib¹¹³, S. Hassani¹³⁶, S. Haug¹⁸, R. Hauser⁹¹, L. Hauswald⁴⁶, M. Havranek¹²⁷, C.M. Hawkes¹⁹, R.J. Hawking³², D. Hayden⁹¹, C.P. Hays¹²⁰, J.M. Hays⁷⁷, H.S. Hayward⁷⁵, S.J. Haywood¹³¹, S.J. Head¹⁹, T. Heck⁸⁴, V. Hedberg⁸², L. Heelan⁸, S. Heim¹²², T. Heim¹⁶, B. Heinemann¹⁶, J.J. Heinrich¹⁰⁰, L. Heinrich¹¹⁰, C. Heinz⁵⁴, J. Hejbal¹²⁷, L. Helary²⁴, S. Hellman^{146a,146b}, C. Hensens³², J. Henderson¹²⁰, R.C.W. Henderson⁷³, Y. Heng¹⁷², S. Henkelmann¹⁶⁷, A.M. Henriques Correia³², S. Henrot-Versille¹¹⁷, G.H. Herbert¹⁷, Y. Hernández Jiménez¹⁶⁶, G. Herten⁵⁰, R. Hertenberger¹⁰⁰, L. Hervas³², G.G. Hesketh⁷⁹, N.P. Hessey¹⁰⁷, J.W. Hetherly⁴², R. Hickling⁷⁷, E. Higón-Rodríguez¹⁶⁶, E. Hill¹⁶⁸, J.C. Hill³⁰, K.H. Hiller⁴⁴, S.J. Hillier¹⁹, I. Hinchliffe¹⁶, E. Hines¹²², R.R. Hinman¹⁶, M. Hirose⁵⁰, D. Hirschbuehl¹⁷⁴, J. Hobbs¹⁴⁸, N. Hod^{159a}, M.C. Hodgkinson¹³⁹, P. Hodgson¹³⁹, A. Hoecker³², M.R. Hoferkamp¹⁰⁵, F. Hoenig¹⁰⁰, D. Hohn²³, T.R. Holmes¹⁶, M. Homann⁴⁵, T.M. Hong¹²⁵, B.H. Hooberman¹⁶⁵, W.H. Hopkins¹¹⁶, Y. Horii¹⁰³, A.J. Horton¹⁴², J.-Y. Hostachy⁵⁷, S. Hou¹⁵¹, A. Hoummada^{135a}, J. Howarth⁴⁴, M. Hrabovsky¹¹⁵, I. Hristova¹⁷, J. Hrivnac¹¹⁷, T. Hryn'ova⁵, A. Hrynevich⁹⁴, C. Hsu^{145c}, P.J. Hsu^{151,t}, S.-C. Hsu¹³⁸, D. Hu³⁷, Q. Hu^{35b}, Y. Huang⁴⁴, Z. Hubacek¹²⁸, F. Hubaut⁸⁶, F. Huegging²³, T.B. Huffman¹²⁰, E.W. Hughes³⁷, G. Hughes⁷³, M. Huhtinen³², P. Huo¹⁴⁸, N. Huseynov^{66,b}, J. Huston⁹¹, J. Huth⁵⁸, G. Iacobucci⁵¹, G. Iakovidis²⁷, I. Ibragimov¹⁴¹, L. Iconomidou-Fayard¹¹⁷, E. Ideal¹⁷⁵, Z. Idrissi^{135e}, P. Iengo³², O. Igonkina^{107,u}, T. Iizawa¹⁷⁰, Y. Ikegami⁶⁷, M. Ikeno⁶⁷, Y. Ilchenko^{11,v}, D. Iliadis¹⁵⁴, N. Ilic¹⁴³, T. Ince¹⁰¹, G. Introzzi^{121a,121b}, P. Ioannou^{9,*}, M. Iodice^{134a}, K. Iordanidou³⁷, V. Ippolito⁵⁸, N. Ishijima¹¹⁸, M. Ishino⁶⁹, M. Ishitsuka¹⁵⁷, R. Ishmukhametov¹¹¹, C. Issever¹²⁰, S. Istin^{20a}, F. Ito¹⁶⁰, J.M. Iturbe Ponce⁸⁵, R. Iuppa^{133a,133b}, W. Iwanski⁴¹, H. Iwasaki⁶⁷, J.M. Izen⁴³, V. Izzo^{104a}, S. Jabbar³, B. Jackson¹²², M. Jackson⁷⁵, P. Jackson¹, V. Jain², K.B. Jakobi⁸⁴, K. Jakobs⁵⁰, S. Jakobsen³², T. Jakoubek¹²⁷, D.O. Jamin¹¹⁴, D.K. Jana⁸⁰, E. Jansen⁷⁹, R. Jansky⁶³, J. Janssen²³, M. Janus⁵⁶, G. Jarlskog⁸², N. Javadov^{66,b}, T. Javůrek⁵⁰, F. Jeanneau¹³⁶, L. Jeanty¹⁶, J. Jejelava^{53a,w}, G.-Y. Jeng¹⁵⁰, D. Jennens⁸⁹, P. Jenni^{50,x}, J. Jentzsch⁴⁵, C. Jeske¹⁶⁹, S. Jézéquel⁵, H. Ji¹⁷², J. Jia¹⁴⁸, H. Jiang⁶⁵, Y. Jiang^{35b}, S. Jiggins⁷⁹, J. Jimenez Pena¹⁶⁶, S. Jin^{35a}, A. Jinaru^{28b}, O. Jinnouchi¹⁵⁷, P. Johansson¹³⁹, K.A. Johns⁷, W.J. Johnson¹³⁸, K. Jon-And^{146a,146b}, G. Jones¹⁶⁹, R.W.L. Jones⁷³, S. Jones⁷, T.J. Jones⁷⁵, J. Jongmanns^{59a}, P.M. Jorge^{126a,126b}, J. Jovicevic^{159a}, X. Ju¹⁷², A. Juste Rozas^{13,r}, M.K. Köhler¹⁷¹, A. Kaczmarska⁴¹, M. Kado¹¹⁷, H. Kagan¹¹¹, M. Kagan¹⁴³, S.J. Kahn⁸⁶, E. Kajomovitz⁴⁷, C.W. Kalderon¹²⁰, A. Kaluza⁸⁴, S. Kama⁴², A. Kamenshchikov¹³⁰, N. Kanaya¹⁵⁵, S. Kaneti³⁰, L. Kanjir⁷⁶, V.A. Kantserov⁹⁸, J. Kanzaki⁶⁷, B. Kaplan¹¹⁰, L.S. Kaplan¹⁷², A. Kapliy³³, D. Kar^{145c}, K. Karakostas¹⁰, A. Karamaoun³, N. Karastathis¹⁰, M.J. Kareem⁵⁶, E. Karentzos¹⁰, M. Karnevskiy⁸⁴, S.N. Karpov⁶⁶, Z.M. Karpova⁶⁶, K. Karthik¹¹⁰, V. Kartvelishvili⁷³, A.N. Karyukhin¹³⁰, K. Kasahara¹⁶⁰, L. Kashif¹⁷², R.D. Kass¹¹¹, A. Kastanas¹⁵, Y. Kataoka¹⁵⁵, C. Kato¹⁵⁵, A. Katre⁵¹, J. Katzy⁴⁴, K. Kawagoe⁷¹, T. Kawamoto¹⁵⁵, G. Kawamura⁵⁶, S. Kazama¹⁵⁵, V.F. Kazanin^{109,c}, R. Keeler¹⁶⁸, R. Kehoe⁴², J.S. Keller⁴⁴, J.J. Kempster⁷⁸, K. Kentaro¹⁰³, H. Keoshkerian¹⁵⁸, O. Kepka¹²⁷, B.P. Kerševan⁷⁶, S. Kersten¹⁷⁴, R.A. Keyes⁸⁸, M. Khader¹⁶⁵, F. Khalil-zada¹², A. Khanov¹¹⁴, A.G. Kharlamov^{109,c}, T.J. Khoo⁵¹, V. Khovanskii⁹⁷, E. Khramov⁶⁶, J. Khubua^{53b,y}, S. Kido⁶⁸, H.Y. Kim⁸, S.H. Kim¹⁶⁰, Y.K. Kim³³, N. Kimura¹⁵⁴, O.M. Kind¹⁷, B.T. King⁷⁵, M. King¹⁶⁶, S.B. King¹⁶⁷, J. Kirk¹³¹, A.E. Kiryunin¹⁰¹,

T. Kishimoto⁶⁸, D. Kisiielewska^{40a}, F. Kiss⁵⁰, K. Kiuchi¹⁶⁰, O. Kivernyk¹³⁶, E. Kladiva^{144b}, M.H. Klein³⁷, M. Klein⁷⁵, U. Klein⁷⁵, K. Kleinknecht⁸⁴, P. Klimek¹⁰⁸, A. Klimentov²⁷, R. Klingenberg⁴⁵, J.A. Klinger¹³⁹, T. Klioutchnikova³², E.-E. Kluge^{59a}, P. Kluit¹⁰⁷, S. Kluth¹⁰¹, J. Knapik⁴¹, E. Kneringer⁶³, E.B.F.G. Knoop⁸⁶, A. Knue⁵⁵, A. Kobayashi¹⁵⁵, D. Kobayashi¹⁵⁷, T. Kobayashi¹⁵⁵, M. Kobel⁴⁶, M. Kocian¹⁴³, P. Kodys¹²⁹, T. Koffas³¹, E. Koffeman¹⁰⁷, T. Koi¹⁴³, H. Kolanoski¹⁷, M. Kolb^{59b}, I. Koletsou⁵, A.A. Komar^{96,*}, Y. Komori¹⁵⁵, T. Kondo⁶⁷, N. Kondrashova⁴⁴, K. Köneke⁵⁰, A.C. König¹⁰⁶, T. Kono^{67,z}, R. Konoplich^{110,aa}, N. Konstantinidis⁷⁹, R. Kopeliansky⁶², S. Koperny^{40a}, L. Köpke⁸⁴, A.K. Kopp⁵⁰, K. Korcyl⁴¹, K. Kordas¹⁵⁴, A. Korn⁷⁹, A.A. Korol^{109,c}, I. Korolkov¹³, E.V. Korolkova¹³⁹, O. Kortner¹⁰¹, S. Kortner¹⁰¹, T. Kosek¹²⁹, V.V. Kostyukhin²³, A. Kotwal⁴⁷, A. Kourkouveli-Charalampidi¹⁵⁴, C. Kourkouvelis⁹, V. Kouskoura²⁷, A.B. Kowalewska⁴¹, R. Kowalewski¹⁶⁸, T.Z. Kowalski^{40a}, C. Kozakai¹⁵⁵, W. Kozanecki¹³⁶, A.S. Kozhin¹³⁰, V.A. Kramarenko⁹⁹, G. Kramberger⁷⁶, D. Krasnopevtsev⁹⁸, M.W. Krasny⁸¹, A. Krasznahorkay³², J.K. Kraus²³, A. Kravchenko²⁷, M. Kretz^{59c}, J. Kretzschmar⁷⁵, K. Kreutzfeldt⁵⁴, P. Krieger¹⁵⁸, K. Krizka³³, K. Kroeninger⁴⁵, H. Kroha¹⁰¹, J. Kroll¹²², J. Kroseberg²³, J. Krstic¹⁴, U. Kruchonak⁶⁶, H. Krüger²³, N. Krumnack⁶⁵, A. Kruse¹⁷², M.C. Kruse⁴⁷, M. Kruskal²⁴, T. Kubota⁸⁹, H. Kucuk⁷⁹, S. Kuday^{4b}, J.T. Kuechler¹⁷⁴, S. Kuehn⁵⁰, A. Kugel^{59c}, F. Kuger¹⁷³, A. Kuhl¹³⁷, T. Kuhl⁴⁴, V. Kukhtin⁶⁶, R. Kukla¹³⁶, Y. Kulchitsky⁹³, S. Kuleshov^{34b}, M. Kuna^{132a,132b}, T. Kunigo⁶⁹, A. Kupco¹²⁷, H. Kurashige⁶⁸, Y.A. Kurochkin⁹³, V. Kus¹²⁷, E.S. Kuwertz¹⁶⁸, M. Kuze¹⁵⁷, J. Kvita¹¹⁵, T. Kwan¹⁶⁸, D. Kyriazopoulos¹³⁹, A. La Rosa¹⁰¹, J.L. La Rosa Navarro^{26d}, L. La Rotonda^{39a,39b}, C. Lacasta¹⁶⁶, F. Lacava^{132a,132b}, J. Lacey³¹, H. Lacker¹⁷, D. Lacour⁸¹, V.R. Lacuesta¹⁶⁶, E. Ladygin⁶⁶, R. Lafaye⁵, B. Laforge⁸¹, T. Lagouri¹⁷⁵, S. Lai⁵⁶, S. Lammers⁶², W. Lampl⁷, E. Lançon¹³⁶, U. Landgraf⁵⁰, M.P.J. Landon⁷⁷, M.C. Lanfermann⁵¹, V.S. Lang^{59a}, J.C. Lange¹³, A.J. Lankford¹⁶², F. Lanni²⁷, K. Lantzsche²³, A. Lanza^{121a}, S. Laplace⁸¹, C. Lapoire³², J.F. Laporte¹³⁶, T. Lari^{92a}, F. Lasagni Manghi^{22a,22b}, M. Lassnig³², P. Laurelli⁴⁹, W. Lavrijsen¹⁶, A.T. Law¹³⁷, P. Laycock⁷⁵, T. Lazovich⁵⁸, M. Lazzaroni^{92a,92b}, B. Le⁸⁹, O. Le Dortz⁸¹, E. Le Guirriec⁸⁶, E.P. Le Quilleuc¹³⁶, M. LeBlanc¹⁶⁸, T. LeCompte⁶, F. Ledroit-Guillon⁵⁷, C.A. Lee²⁷, S.C. Lee¹⁵¹, L. Lee¹, G. Lefebvre⁸¹, M. Lefebvre¹⁶⁸, F. Legger¹⁰⁰, C. Leggett¹⁶, A. Lehan⁷⁵, G. Lehmann Miotto³², X. Lei⁷, W.A. Leight³¹, A. Leisos^{154,ab}, A.G. Leister¹⁷⁵, M.A.L. Leite^{26d}, R. Leitner¹²⁹, D. Lellouch¹⁷¹, B. Lemmer⁵⁶, K.J.C. Leney⁷⁹, T. Lenz²³, B. Lenzi³², R. Leone⁷, S. Leone^{124a,124b}, C. Leonidopoulos⁴⁸, S. Leontsinis¹⁰, G. Lerner¹⁴⁹, C. Leroy⁹⁵, A.A.J. Lesage¹³⁶, C.G. Lester³⁰, M. Levchenko¹²³, J. Levêque⁵, D. Levin⁹⁰, L.J. Levinson¹⁷¹, M. Levy¹⁹, D. Lewis⁷⁷, A.M. Leyko²³, M. Leyton⁴³, B. Li^{35b,o}, H. Li¹⁴⁸, H.L. Li³³, L. Li⁴⁷, L. Li^{35e}, Q. Li^{35a}, S. Li⁴⁷, X. Li⁸⁵, Y. Li¹⁴¹, Z. Liang^{35a}, B. Liberti^{133a}, A. Liblong¹⁵⁸, P. Lichard³², K. Lie¹⁶⁵, J. Liebal²³, W. Liebig¹⁵, A. Limosani¹⁵⁰, S.C. Lin^{151,ac}, T.H. Lin⁸⁴, B.E. Lindquist¹⁴⁸, A.E. Lioni⁵¹, E. Lipeles¹²², A. Lipniacka¹⁵, M. Lisovsky^{59b}, T.M. Liss¹⁶⁵, A. Lister¹⁶⁷, A.M. Litke¹³⁷, B. Liu^{151,ad}, D. Liu¹⁵¹, H. Liu⁹⁰, H. Liu²⁷, J. Liu⁸⁶, J.B. Liu^{35b}, K. Liu⁸⁶, L. Liu¹⁶⁵, M. Liu⁴⁷, M. Liu^{35b}, Y.L. Liu^{35b}, Y. Liu^{35b}, M. Livan^{121a,121b}, A. Lleres⁵⁷, J. Llorente Merino^{35a}, S.L. Lloyd⁷⁷, F. Lo Sterzo¹⁵¹, E. Lobodzinska⁴⁴, P. Loch⁷, W.S. Lockman¹³⁷, F.K. Loebinger⁸⁵, A.E. Loeschall-Jensen³⁸, K.M. Loew²⁵, A. Loginov¹⁷⁵, T. Lohse¹⁷, K. Lohwasser⁴⁴, M. Lokajicek¹²⁷, B.A. Long²⁴, J.D. Long¹⁶⁵, R.E. Long⁷³, L. Longo^{74a,74b}, K.A. Looper¹¹¹, L. Lopes^{126a}, D. Lopez Mateos⁵⁸, B. Lopez Paredes¹³⁹, I. Lopez Paz¹³, A. Lopez Solis⁸¹, J. Lorenz¹⁰⁰, N. Lorenzo Martinez⁶², M. Losada²¹, P.J. Lösel¹⁰⁰, X. Lou^{35a}, A. Lounis¹¹⁷, J. Love⁶, P.A. Love⁷³, H. Lu^{61a}, N. Lu⁹⁰, H.J. Lubatti¹³⁸, C. Luci^{132a,132b}, A. Lucotte⁵⁷, C. Luedtke⁵⁰, F. Luehring⁶², W. Lukas⁶³, L. Luminari^{132a}, O. Lundberg^{146a,146b}, B. Lund-Jensen¹⁴⁷, P.M. Luzi⁸¹, D. Lynn²⁷, R. Lysak¹²⁷, E. Lytken⁸², V. Lyubushkin⁶⁶, H. Ma²⁷, L.L. Ma^{35d}, Y. Ma^{35d}, G. Maccarrone⁴⁹, A. Macchiolo¹⁰¹, C.M. Macdonald¹³⁹, B. Maček⁷⁶, J. Machado Miguens^{122,126b}, D. Madaffari⁸⁶, R. Madar³⁶, H.J. Maddocks¹⁶⁴, W.F. Mader⁴⁶, A. Madsen⁴⁴, J. Maeda⁶⁸, S. Maeland¹⁵, T. Maeno²⁷, A. Maevskiy⁹⁹, E. Magradze⁵⁶, J. Mahlstedt¹⁰⁷, C. Maiani¹¹⁷, C. Maidantchik^{26a}, A.A. Maier¹⁰¹, T. Maier¹⁰⁰, A. Maio^{126a,126b,126d}, S. Majewski¹¹⁶, Y. Makida⁶⁷, N. Makovec¹¹⁷, B. Malaescu⁸¹, Pa. Malecki⁴¹, V.P. Maleev¹²³, F. Malek⁵⁷, U. Mallik⁶⁴, D. Malon⁶, C. Malone¹⁴³, S. Maltezos¹⁰, S. Malyukov³², J. Mamuzic¹⁶⁶, G. Mancini⁴⁹, B. Mandelli³², L. Mandelli^{92a}, I. Mandić⁷⁶, J. Maneira^{126a,126b}, L. Manhaes de Andrade Filho^{26b}, J. Manjarres Ramos^{159b}, A. Mann¹⁰⁰, A. Manousos³², B. Mansoulie¹³⁶, J.D. Mansour^{35a}, R. Mantifel⁸⁸, M. Mantoani⁵⁶, S. Manzoni^{92a,92b}, L. Mapelli³², G. Marceca²⁹, L. March⁵¹, G. Marchiori⁸¹, M. Marcisovsky¹²⁷, M. Marjanovic¹⁴, D.E. Marley⁹⁰, F. Marroquim^{26a},

S.P. Marsden⁸⁵, Z. Marshall¹⁶, S. Marti-Garcia¹⁶⁶, B. Martin⁹¹, T.A. Martin¹⁶⁹, V.J. Martin⁴⁸, B. Martin dit Latour¹⁵, M. Martinez^{13,r}, V.I. Martinez Outschoorn¹⁶⁵, S. Martin-Haugh¹³¹, V.S. Martoiu^{28b}, A.C. Martyniuk⁷⁹, M. Marx¹³⁸, A. Marzin³², L. Masetti⁸⁴, T. Mashimo¹⁵⁵, R. Mashinistov⁹⁶, J. Masik⁸⁵, A.L. Maslennikov^{109,c}, I. Massa^{22a,22b}, L. Massa^{22a,22b}, P. Mastrandrea⁵, A. Mastroberardino^{39a,39b}, T. Masubuchi¹⁵⁵, P. Mättig¹⁷⁴, J. Mattmann⁸⁴, J. Maurer^{28b}, S.J. Maxfield⁷⁵, D.A. Maximov^{109,c}, R. Mazini¹⁵¹, S.M. Mazza^{92a,92b}, N.C. Mc Fadden¹⁰⁵, G. Mc Goldrick¹⁵⁸, S.P. Mc Kee⁹⁰, A. McCarn⁹⁰, R.L. McCarthy¹⁴⁸, T.G. McCarthy¹⁰¹, L.I. McClymont⁷⁹, E.F. McDonald⁸⁹, J.A. Mcfayden⁷⁹, G. Mchedlidze⁵⁶, S.J. McMahon¹³¹, R.A. McPherson^{168,l}, M. Medinnis⁴⁴, S. Meehan¹³⁸, S. Mehlhase¹⁰⁰, A. Mehta⁷⁵, K. Meier^{59a}, C. Meineck¹⁰⁰, B. Meirose⁴³, D. Melini¹⁶⁶, B.R. Mellado Garcia^{145c}, M. Melo^{144a}, F. Meloni¹⁸, A. Mengarelli^{22a,22b}, S. Menke¹⁰¹, E. Meoni¹⁶¹, S. Mergelmeyer¹⁷, P. Mermoud⁵¹, L. Merola^{104a,104b}, C. Meroni^{92a}, F.S. Merritt³³, A. Messina^{132a,132b}, J. Metcalfe⁶, A.S. Mete¹⁶², C. Meyer⁸⁴, C. Meyer¹²², J.-P. Meyer¹³⁶, J. Meyer¹⁰⁷, H. Meyer Zu Thoenhausen^{59a}, F. Miano¹⁴⁹, R.P. Middleton¹³¹, S. Miglioranza^{52a,52b}, L. Mijović²³, G. Mikenberg¹⁷¹, M. Mikestikova¹²⁷, M. Mikuž⁷⁶, M. Milesi⁸⁹, A. Milic⁶³, D.W. Miller³³, C. Mills⁴⁸, A. Milov¹⁷¹, D.A. Milstead^{146a,146b}, A.A. Minaenko¹³⁰, Y. Minami¹⁵⁵, I.A. Minashvili⁶⁶, A.I. Mincer¹¹⁰, B. Mindur^{40a}, M. Mineev⁶⁶, Y. Ming¹⁷², L.M. Mir¹³, K.P. Mistry¹²², T. Mitani¹⁷⁰, J. Mitrevski¹⁰⁰, V.A. Mitsou¹⁶⁶, A. Miucci⁵¹, P.S. Miyagawa¹³⁹, J.U. Mjörnmark⁸², T. Moa^{146a,146b}, K. Mochizuki⁹⁵, S. Mohapatra³⁷, S. Molander^{146a,146b}, R. Moles-Valls²³, R. Monden⁶⁹, M.C. Mondragon⁹¹, K. Mönig⁴⁴, J. Monk³⁸, E. Monnier⁸⁶, A. Montalbano¹⁴⁸, J. Montejo Berlingen³², F. Monticelli⁷², S. Monzani^{92a,92b}, R.W. Moore³, N. Morange¹¹⁷, D. Moreno²¹, M. Moreno Llacer⁵⁶, P. Morettini^{52a}, D. Mori¹⁴², T. Mori¹⁵⁵, M. Morii⁵⁸, M. Morinaga¹⁵⁵, V. Morisbak¹¹⁹, S. Moritz⁸⁴, A.K. Morley¹⁵⁰, G. Mornacchi³², J.D. Morris⁷⁷, S.S. Mortensen³⁸, L. Morvaj¹⁴⁸, M. Mosidze^{53b}, J. Moss¹⁴³, K. Motohashi¹⁵⁷, R. Mount¹⁴³, E. Mountricha²⁷, S.V. Mouraviev^{96,*}, E.J.W. Moyse⁸⁷, S. Muanza⁸⁶, R.D. Mudd¹⁹, F. Mueller¹⁰¹, J. Mueller¹²⁵, R.S.P. Mueller¹⁰⁰, T. Mueller³⁰, D. Muenstermann⁷³, P. Mullen⁵⁵, G.A. Mullier¹⁸, F.J. Munoz Sanchez⁸⁵, J.A. Murillo Quijada¹⁹, W.J. Murray^{169,131}, H. Musheghyan⁵⁶, M. Muškinja⁷⁶, A.G. Myagkov^{130,ae}, M. Myska¹²⁸, B.P. Nachman¹⁴³, O. Nackenhorst⁵¹, K. Nagai¹²⁰, R. Nagai^{67,z}, K. Nagano⁶⁷, Y. Nagasaka⁶⁰, K. Nagata¹⁶⁰, M. Nagel⁵⁰, E. Nagy⁸⁶, A.M. Nairz³², Y. Nakahama³², K. Nakamura⁶⁷, T. Nakamura¹⁵⁵, I. Nakano¹¹², H. Namasivayam⁴³, R.F. Naranjo Garcia⁴⁴, R. Narayan¹¹, D.I. Narrias Villar^{59a}, I. Naryshkin¹²³, T. Naumann⁴⁴, G. Navarro²¹, R. Nayyar⁷, H.A. Neal⁹⁰, P.Yu. Nechaeva⁹⁶, T.J. Neep⁸⁵, P.D. Nef¹⁴³, A. Negri^{121a,121b}, M. Negrini^{22a}, S. Nektarijevic¹⁰⁶, C. Nellist¹¹⁷, A. Nelson¹⁶², S. Nemecek¹²⁷, P. Nemethy¹¹⁰, A.A. Nepomuceno^{26a}, M. Nessi^{32,af}, M.S. Neubauer¹⁶⁵, M. Neumann¹⁷⁴, R.M. Neves¹¹⁰, P. Nevski²⁷, P.R. Newman¹⁹, D.H. Nguyen⁶, T. Nguyen Manh⁹⁵, R.B. Nickerson¹²⁰, R. Nicolaidou¹³⁶, J. Nielsen¹³⁷, A. Nikiforov¹⁷, V. Nikolaenko^{130,ae}, I. Nikolic-Audit⁸¹, K. Nikolopoulos¹⁹, J.K. Nilsen¹¹⁹, P. Nilsson²⁷, Y. Ninomiya¹⁵⁵, A. Nisati^{132a}, R. Nisius¹⁰¹, T. Nobe¹⁵⁵, M. Nomachi¹¹⁸, I. Nomidis³¹, T. Nooney⁷⁷, S. Norberg¹¹³, M. Nordberg³², N. Norjoharuddeen¹²⁰, O. Novgorodova⁴⁶, S. Nowak¹⁰¹, M. Nozaki⁶⁷, L. Nozka¹¹⁵, K. Ntekas¹⁰, E. Nurse⁷⁹, F. Nuti⁸⁹, F. O'grady⁷, D.C. O'Neil¹⁴², A.A. O'Rourke⁴⁴, V. O'Shea⁵⁵, F.G. Oakham^{31,d}, H. Oberlack¹⁰¹, T. Obermann²³, J. Ocariz⁸¹, A. Ochi⁶⁸, I. Ochoa³⁷, J.P. Ochoa-Ricoux^{34a}, S. Oda⁷¹, S. Odaka⁶⁷, H. Ogren⁶², A. Oh⁸⁵, S.H. Oh⁴⁷, C.C. Ohm¹⁶, H. Ohman¹⁶⁴, H. Oide³², H. Okawa¹⁶⁰, Y. Okumura³³, T. Okuyama⁶⁷, A. Olariu^{28b}, L.F. Oleiro Seabra^{126a}, S.A. Olivares Pino⁴⁸, D. Oliveira Damazio²⁷, A. Olszewski⁴¹, J. Olszowska⁴¹, A. Onofre^{126a,126e}, K. Onogi¹⁰³, P.U.E. Onyisi^{11,v}, M.J. Oreglia³³, Y. Oren¹⁵³, D. Orestano^{134a,134b}, N. Orlando^{61b}, R.S. Orr¹⁵⁸, B. Osculati^{52a,52b}, R. Ospanov⁸⁵, G. Otero y Garzon²⁹, H. Otono⁷¹, M. Ouchrif^{135d}, F. Ould-Saada¹¹⁹, A. Ouraou¹³⁶, K.P. Oussoren¹⁰⁷, Q. Ouyang^{35a}, M. Owen⁵⁵, R.E. Owen¹⁹, V.E. Ozcan^{20a}, N. Ozturk⁸, K. Pachal¹⁴², A. Pacheco Pages¹³, L. Pacheco Rodriguez¹³⁶, C. Padilla Aranda¹³, M. Pagáčová⁵⁰, S. Pagan Griso¹⁶, F. Paige²⁷, P. Pais⁸⁷, K. Pajchel¹¹⁹, G. Palacino^{159b}, S. Palestini³², M. Palka^{40b}, D. Pallin³⁶, A. Palma^{126a,126b}, E. St. Panagiotopoulou¹⁰, C.E. Pandini⁸¹, J.G. Panduro Vazquez⁷⁸, P. Pani^{146a,146b}, S. Panitkin²⁷, D. Pantea^{28b}, L. Paolozzi⁵¹, Th.D. Papadopoulou¹⁰, K. Papageorgiou¹⁵⁴, A. Paramonov⁶, D. Paredes Hernandez¹⁷⁵, A.J. Parker⁷³, M.A. Parker³⁰, K.A. Parker¹³⁹, F. Parodi^{52a,52b}, J.A. Parsons³⁷, U. Parzefall⁵⁰, V.R. Pascuzzi¹⁵⁸, E. Pasqualucci^{132a}, S. Passaggio^{52a}, Fr. Pastore⁷⁸, G. Pásztor^{31,ag}, S. Pataia¹⁷⁴, J.R. Pater⁸⁵, T. Pauly³², J. Pearce¹⁶⁸, B. Pearson¹¹³, L.E. Pedersen³⁸, M. Pedersen¹¹⁹, S. Pedraza Lopez¹⁶⁶, R. Pedro^{126a,126b}, S.V. Peleganchuk^{109,c}, D. Pelikan¹⁶⁴, O. Penc¹²⁷, C. Peng^{35a},

H. Peng^{35b}, J. Penwell⁶², B.S. Peralva^{26b}, M.M. Perego¹³⁶, D.V. Perepelitsa²⁷, E. Perez Codina^{159a}, L. Perini^{92a,92b}, H. Pernegger³², S. Perrella^{104a,104b}, R. Peschke⁴⁴, V.D. Peshekhonov⁶⁶, K. Peters⁴⁴, R.F.Y. Peters⁸⁵, B.A. Petersen³², T.C. Petersen³⁸, E. Petit⁵⁷, A. Petridis¹, C. Petridou¹⁵⁴, P. Petroff¹¹⁷, E. Petrolo^{132a}, M. Petrov¹²⁰, F. Petrucci^{134a,134b}, N.E. Pettersson⁸⁷, A. Peyaud¹³⁶, R. Pezoa^{34b}, P.W. Phillips¹³¹, G. Piacquadio¹⁴³, E. Pianori¹⁶⁹, A. Picazio⁸⁷, E. Piccaro⁷⁷, M. Piccinini^{22a,22b}, M.A. Pickering¹²⁰, R. Piegai²⁹, J.E. Pilcher³³, A.D. Pilkington⁸⁵, A.W.J. Pin⁸⁵, M. Pinamonti^{163a,163c,ah}, J.L. Pinfold³, A. Pingel³⁸, S. Pires⁸¹, H. Pirumov⁴⁴, M. Pitt¹⁷¹, L. Plazak^{144a}, M.-A. Pleier²⁷, V. Pleskot⁸⁴, E. Plotnikova⁶⁶, P. Plucinski⁹¹, D. Pluth⁶⁵, R. Poettgen^{146a,146b}, L. Poggioli¹¹⁷, D. Pohl²³, G. Polesello^{121a}, A. Poley⁴⁴, A. Policicchio^{39a,39b}, R. Polifka¹⁵⁸, A. Polini^{22a}, C.S. Pollard⁵⁵, V. Polychronakos²⁷, K. Pommès³², L. Pontecorvo^{132a}, B.G. Pope⁹¹, G.A. Popeneciu^{28c}, D.S. Popovic¹⁴, A. Poppleton³², S. Pospisil¹²⁸, K. Potamianos¹⁶, I.N. Potrap⁶⁶, C.J. Potter³⁰, C.T. Potter¹¹⁶, G. Poulard³², J. Poveda³², V. Pozdnyakov⁶⁶, M.E. Pozo Astigarraga³², P. Pralavorio⁸⁶, A. Pranko¹⁶, S. Prell⁶⁵, D. Price⁸⁵, L.E. Price⁶, M. Primavera^{74a}, S. Prince⁸⁸, K. Prokofiev^{61c}, F. Prokoshin^{34b}, S. Protopopescu²⁷, J. Proudfoot⁶, M. Przybycien^{40a}, D. Puddu^{134a,134b}, M. Purohit^{27,ai}, P. Puzo¹¹⁷, J. Qian⁹⁰, G. Qin⁵⁵, Y. Qin⁸⁵, A. Quadt⁵⁶, W.B. Quayle^{163a,163b}, M. Queitsch-Maitland⁸⁵, D. Quilty⁵⁵, S. Raddum¹¹⁹, V. Radeka²⁷, V. Radescu^{59b}, S.K. Radhakrishnan¹⁴⁸, P. Radloff¹¹⁶, P. Rados⁸⁹, F. Ragusa^{92a,92b}, G. Rahal¹⁷⁷, J.A. Raine⁸⁵, S. Rajagopalan²⁷, M. Rammensee³², C. Rangel-Smith¹⁶⁴, M.G. Ratti^{92a,92b}, F. Rauscher¹⁰⁰, S. Rave⁸⁴, T. Ravenscroft⁵⁵, I. Ravinovich¹⁷¹, M. Raymond³², A.L. Read¹¹⁹, N.P. Readoff⁷⁵, M. Reale^{74a,74b}, D.M. Rebuffi^{121a,121b}, A. Redelbach¹⁷³, G. Redlinger²⁷, R. Reece¹³⁷, K. Reeves⁴³, L. Rehnisch¹⁷, J. Reichert¹²², H. Reisin²⁹, C. Rembser³², H. Ren^{35a}, M. Rescigno^{132a}, S. Resconi^{92a}, O.L. Rezanova^{109,c}, P. Reznicek¹²⁹, R. Rezvani⁹⁵, R. Richter¹⁰¹, S. Richter⁷⁹, E. Richter-Was^{40b}, O. Ricken²³, M. Ridel⁸¹, P. Rieck¹⁷, C.J. Riegel¹⁷⁴, J. Rieger⁵⁶, O. Rifki¹¹³, M. Rijssenbeek¹⁴⁸, A. Rimoldi^{121a,121b}, M. Rimoldi¹⁸, L. Rinaldi^{22a}, B. Ristić⁵¹, E. Ritsch³², I. Riu¹³, F. Rizatdinova¹¹⁴, E. Rizvi⁷⁷, C. Rizzi¹³, S.H. Robertson^{88,l}, A. Robichaud-Veronneau⁸⁸, D. Robinson³⁰, J.E.M. Robinson⁴⁴, A. Robson⁵⁵, C. Roda^{124a,124b}, Y. Rodina⁸⁶, A. Rodriguez Perez¹³, D. Rodriguez Rodriguez¹⁶⁶, S. Roe³², C.S. Rogan⁵⁸, O. Röhne¹¹⁹, A. Romaniouk⁹⁸, M. Romano^{22a,22b}, S.M. Romano Saez³⁶, E. Romero Adam¹⁶⁶, N. Rompotis¹³⁸, M. Ronzani⁵⁰, L. Roos⁸¹, E. Ros¹⁶⁶, S. Rosati^{132a}, K. Rosbach⁵⁰, P. Rose¹³⁷, O. Rosenthal¹⁴¹, N.-A. Rosien⁵⁶, V. Rossetti^{146a,146b}, E. Rossi^{104a,104b}, L.P. Rossi^{52a}, J.H.N. Rosten³⁰, R. Rosten¹³⁸, M. Rotaru^{28b}, I. Roth¹⁷¹, J. Rothberg¹³⁸, D. Rousseau¹¹⁷, C.R. Royon¹³⁶, A. Rozanov⁸⁶, Y. Rozen¹⁵², X. Ruan^{145c}, F. Rubbo¹⁴³, M.S. Rudolph¹⁵⁸, F. Rühr⁵⁰, A. Ruiz-Martinez³¹, Z. Rurikova⁵⁰, N.A. Rusakovich⁶⁶, A. Ruschke¹⁰⁰, H.L. Russell¹³⁸, J.P. Rutherford⁷, N. Ruthmann³², Y.F. Ryabov¹²³, M. Rybar¹⁶⁵, G. Rybkin¹¹⁷, S. Ryu⁶, A. Ryzhov¹³⁰, G.F. Rzehorz⁵⁶, A.F. Saavedra¹⁵⁰, G. Sabato¹⁰⁷, S. Sacerdoti²⁹, H.F.W. Sadrozinski¹³⁷, R. Sadykov⁶⁶, F. Safai Tehrani^{132a}, P. Saha¹⁰⁸, M. Sahinsoy^{59a}, M. Saimpert¹³⁶, T. Saito¹⁵⁵, H. Sakamoto¹⁵⁵, Y. Sakurai¹⁷⁰, G. Salamanna^{134a,134b}, A. Salamon^{133a,133b}, J.E. Salazar Loyola^{34b}, D. Salek¹⁰⁷, P.H. Sales De Bruin¹³⁸, D. Salihagic¹⁰¹, A. Salnikov¹⁴³, J. Salt¹⁶⁶, D. Salvatore^{39a,39b}, F. Salvatore¹⁴⁹, A. Salvucci^{61a}, A. Salzburger³², D. Sammel⁵⁰, D. Sampsonidis¹⁵⁴, A. Sanchez^{104a,104b}, J. Sánchez¹⁶⁶, V. Sanchez Martinez¹⁶⁶, H. Sandaker¹¹⁹, R.L. Sandbach⁷⁷, H.G. Sander⁸⁴, M. Sandhoff¹⁷⁴, C. Sandoval²¹, R. Sandstroem¹⁰¹, D.P.C. Sankey¹³¹, M. Sannino^{52a,52b}, A. Sansoni⁴⁹, C. Santoni³⁶, R. Santonico^{133a,133b}, H. Santos^{126a}, I. Santoyo Castillo¹⁴⁹, K. Sapp¹²⁵, A. Sapronov⁶⁶, J.G. Saraiva^{126a,126d}, B. Sarrazin²³, O. Sasaki⁶⁷, Y. Sasaki¹⁵⁵, K. Sato¹⁶⁰, G. Sauvage^{5,*}, E. Sauvan⁵, G. Savage⁷⁸, P. Savard^{158,d}, C. Sawyer¹³¹, L. Sawyer^{80,q}, J. Saxon³³, C. Sbarra^{22a}, A. Sbrizzi^{22a,22b}, T. Scanlon⁷⁹, D.A. Scannicchio¹⁶², M. Scarcella¹⁵⁰, V. Scarfone^{39a,39b}, J. Schaarschmidt¹⁷¹, P. Schacht¹⁰¹, B.M. Schachtner¹⁰⁰, D. Schaefer³², R. Schaefer⁴⁴, J. Schaeffer⁸⁴, S. Schaepe²³, S. Schaezel^{59b}, U. Schäfer⁸⁴, A.C. Schaffer¹¹⁷, D. Schaile¹⁰⁰, R.D. Schamberger¹⁴⁸, V. Scharf^{59a}, V.A. Schegelsky¹²³, D. Scheirich¹²⁹, M. Schernau¹⁶², C. Schiavi^{52a,52b}, S. Schier¹³⁷, C. Schillo⁵⁰, M. Schioppa^{39a,39b}, S. Schlenker³², K.R. Schmidt-Sommerfeld¹⁰¹, K. Schmieden³², C. Schmitt⁸⁴, S. Schmitt⁴⁴, S. Schmitz⁸⁴, B. Schneider^{159a}, U. Schnoor⁵⁰, L. Schoeffel¹³⁶, A. Schoening^{59b}, B.D. Schoenrock⁹¹, E. Schopf²³, M. Schott⁸⁴, J. Schovancova⁸, S. Schramm⁵¹, M. Schreyer¹⁷³, N. Schuh⁸⁴, A. Schulte⁸⁴, M.J. Schultens²³, H.-C. Schultz-Coulon^{59a}, H. Schulz¹⁷, M. Schumacher⁵⁰, B.A. Schumm¹³⁷, Ph. Schune¹³⁶, A. Schwartzman¹⁴³, T.A. Schwarz⁹⁰, Ph. Schwegler¹⁰¹, H. Schweiger⁸⁵, Ph. Schwemling¹³⁶, R. Schwienhorst⁹¹, J. Schwindling¹³⁶, T. Schwindt²³, G. Sciolla²⁵, F. Scuri^{124a,124b}, F. Scutti⁸⁹,

J. Searcy⁹⁰, P. Seema²³, S.C. Seidel¹⁰⁵, A. Seiden¹³⁷, F. Seifert¹²⁸, J.M. Seixas^{26a}, G. Sekhniaidze^{104a}, K. Sekhon⁹⁰, S.J. Sekula⁴², D.M. Seliverstov^{123,*}, N. Semprini-Cesari^{22a,22b}, C. Serfon¹¹⁹, L. Serin¹¹⁷, L. Serkin^{163a,163b}, M. Sessa^{134a,134b}, R. Seuster¹⁶⁸, H. Severini¹¹³, T. Sfiligoi⁷⁶, F. Sforza³², A. Sfyrle⁵¹, E. Shabalina⁵⁶, N.W. Shaikh^{146a,146b}, L.Y. Shan^{35a}, R. Shang¹⁶⁵, J.T. Shank²⁴, M. Shapiro¹⁶, P.B. Shatalov⁹⁷, K. Shaw^{163a,163b}, S.M. Shaw⁸⁵, A. Shcherbakova^{146a,146b}, C.Y. Shehu¹⁴⁹, P. Sherwood⁷⁹, L. Shi^{151,aj}, S. Shimizu⁶⁸, C.O. Shimmin¹⁶², M. Shimojima¹⁰², M. Shiyakova^{66,ak}, A. Shmeleva⁹⁶, D. Shoaleh Saadi⁹⁵, M.J. Shochet³³, S. Shojaii^{92a,92b}, S. Shrestha¹¹¹, E. Shulga⁹⁸, M.A. Shupe⁷, P. Sicho¹²⁷, A.M. Sickles¹⁶⁵, P.E. Sidebo¹⁴⁷, O. Sidiropoulou¹⁷³, D. Sidorov¹¹⁴, A. Sidoti^{22a,22b}, F. Siegert⁴⁶, Dj. Sijacki¹⁴, J. Silva^{126a,126d}, S.B. Silverstein^{146a}, V. Simak¹²⁸, O. Simard⁵, Lj. Simic¹⁴, S. Simion¹¹⁷, E. Simioni⁸⁴, B. Simmons⁷⁹, D. Simon³⁶, M. Simon⁸⁴, P. Sinervo¹⁵⁸, N.B. Sinev¹¹⁶, M. Sioli^{22a,22b}, G. Siragusa¹⁷³, S.Yu. Sivoklov⁹⁹, J. Sjölin^{146a,146b}, M.B. Skinner⁷³, H.P. Skottowe⁵⁸, P. Skubic¹¹³, M. Slater¹⁹, T. Slavicek¹²⁸, M. Slawinska¹⁰⁷, K. Sliwa¹⁶¹, R. Slovak¹²⁹, V. Smakhtin¹⁷¹, B.H. Smart⁵, L. Smestad¹⁵, J. Smiesko^{144a}, S.Yu. Smirnov⁹⁸, Y. Smirnov⁹⁸, L.N. Smirnova^{99,al}, O. Smirnova⁸², M.N.K. Smith³⁷, R.W. Smith³⁷, M. Smizanska⁷³, K. Smolek¹²⁸, A.A. Snesarev⁹⁶, S. Snyder²⁷, R. Sobie^{168,l}, F. Socher⁴⁶, A. Soffer¹⁵³, D.A. Soh¹⁵¹, G. Sokhrannyi⁷⁶, C.A. Solans Sanchez³², M. Solar¹²⁸, E.Yu. Soldatov⁹⁸, U. Soldevila¹⁶⁶, A.A. Solodkov¹³⁰, A. Soloshenko⁶⁶, O.V. Solovyanov¹³⁰, V. Solovyev¹²³, P. Sommer⁵⁰, H. Son¹⁶¹, H.Y. Song^{35b,am}, A. Sood¹⁶, A. Sopczak¹²⁸, V. Sopko¹²⁸, V. Sorin¹³, D. Sosa^{59b}, C.L. Sotiropoulou^{124a,124b}, R. Soualah^{163a,163c}, A.M. Soukharev^{109,c}, D. South⁴⁴, B.C. Sowden⁷⁸, S. Spagnolo^{74a,74b}, M. Spalla^{124a,124b}, M. Spangenberg¹⁶⁹, F. Spanò⁷⁸, D. Sperlich¹⁷, F. Spettel¹⁰¹, R. Spighi^{22a}, G. Spigo³², L.A. Spiller⁸⁹, M. Spousta¹²⁹, R.D. St. Denis^{55,*}, A. Stabile^{92a}, R. Stamen^{59a}, S. Stamm¹⁷, E. Stanecka⁴¹, R.W. Stanek⁶, C. Stancu^{134a}, M. Stancu-Bellu⁴⁴, M.M. Stanitzki⁴⁴, S. Stapnes¹¹⁹, E.A. Starchenko¹³⁰, G.H. Stark³³, J. Stark⁵⁷, P. Staroba¹²⁷, P. Starovoitov^{59a}, S. Stärz³², R. Staszewski⁴¹, P. Steinberg²⁷, B. Stelzer¹⁴², H.J. Stelzer³², O. Stelzer-Chilton^{159a}, H. Stenzel⁵⁴, G.A. Stewart⁵⁵, J.A. Stillings²³, M.C. Stockton⁸⁸, M. Stoebe⁸⁸, G. Stoicea^{28b}, P. Stolte⁵⁶, S. Stonjek¹⁰¹, A.R. Stradling⁸, A. Straessner⁴⁶, M.E. Stramaglia¹⁸, J. Strandberg¹⁴⁷, S. Strandberg^{146a,146b}, A. Strandlie¹¹⁹, M. Strauss¹¹³, P. Strizenec^{144b}, R. Ströhmer¹⁷³, D.M. Strom¹¹⁶, R. Stroynowski⁴², A. Strubig¹⁰⁶, S.A. Stucci¹⁸, B. Stugu¹⁵, N.A. Styles⁴⁴, D. Su¹⁴³, J. Su¹²⁵, S. Suchek^{59a}, Y. Sugaya¹¹⁸, M. Suk¹²⁸, V.V. Sulin⁹⁶, S. Sultansoy^{4c}, T. Sumida⁶⁹, S. Sun⁵⁸, X. Sun^{35a}, J.E. Sundermann⁵⁰, K. Suruliz¹⁴⁹, G. Susinno^{39a,39b}, M.R. Sutton¹⁴⁹, S. Suzuki⁶⁷, M. Svatos¹²⁷, M. Swiatkowski³³, I. Sykora^{144a}, T. Sykora¹²⁹, D. Ta⁵⁰, C. Taccini^{134a,134b}, K. Tackmann⁴⁴, J. Taenzer¹⁵⁸, A. Taffard¹⁶², R. Tahirout^{159a}, N. Taiblum¹⁵³, H. Takai²⁷, R. Takashima⁷⁰, T. Takeshita¹⁴⁰, Y. Takubo⁶⁷, M. Talby⁸⁶, A.A. Talyshv^{109,c}, K.G. Tan⁸⁹, J. Tanaka¹⁵⁵, R. Tanaka¹¹⁷, S. Tanaka⁶⁷, B.B. Tannenwald¹¹¹, S. Tapia Araya^{34b}, S. Tapprogge⁸⁴, S. Tarem¹⁵², G.F. Tartarelli^{92a}, P. Tas¹²⁹, M. Tasevsky¹²⁷, T. Tashiro⁶⁹, E. Tassi^{39a,39b}, A. Tavares Delgado^{126a,126b}, Y. Tayalati^{135e}, A.C. Taylor¹⁰⁵, G.N. Taylor⁸⁹, P.T.E. Taylor⁸⁹, W. Taylor^{159b}, F.A. Teischinger³², P. Teixeira-Dias⁷⁸, K.K. Temming⁵⁰, D. Temple¹⁴², H. Ten Kate³², P.K. Teng¹⁵¹, J.J. Teoh¹¹⁸, F. Tepel¹⁷⁴, S. Terada⁶⁷, K. Terashi¹⁵⁵, J. Terron⁸³, S. Terzo¹⁰¹, M. Testa⁴⁹, R.J. Teuscher^{158,l}, T. Theveneaux-Pelzer⁸⁶, J.P. Thomas¹⁹, J. Thomas-Wilsker⁷⁸, E.N. Thompson³⁷, P.D. Thompson¹⁹, A.S. Thompson⁵⁵, L.A. Thomsen¹⁷⁵, E. Thomson¹²², M. Thomson³⁰, M.J. Tibbetts¹⁶, R.E. Ticse Torres⁸⁶, V.O. Tikhomirov^{96,an}, Yu.A. Tikhonov^{109,c}, S. Timoshenko⁹⁸, P. Tipton¹⁷⁵, S. Tisserant⁸⁶, K. Todome¹⁵⁷, T. Todorov^{5,*}, S. Todorova-Nova¹²⁹, J. Tojo⁷¹, S. Tokár^{144a}, K. Tokushuku⁶⁷, E. Tolley⁵⁸, L. Tomlinson⁸⁵, M. Tomoto¹⁰³, L. Tompkins^{143,ao}, K. Toms¹⁰⁵, B. Tong⁵⁸, E. Torrence¹¹⁶, H. Torres¹⁴², E. Torró Pastor¹³⁸, J. Toth^{86,ap}, F. Touchard⁸⁶, D.R. Tovey¹³⁹, T. Trefzger¹⁷³, A. Tricoli²⁷, I.M. Trigger^{159a}, S. Trincaz-Duvoid⁸¹, M.F. Tripiana¹³, W. Trischuk¹⁵⁸, B. Trocme⁵⁷, A. Trofymov⁴⁴, C. Troncon^{92a}, M. Trotter-McDonald¹⁶, M. Trovatelli¹⁶⁸, L. Truong^{163a,163c}, M. Trzebinski⁴¹, A. Trzupek⁴¹, J.C-L. Tseng¹²⁰, P.V. Tsiarehka⁹³, G. Tsipolitis¹⁰, N. Tsirintanis⁹, S. Tsiskaridze¹³, V. Tsiskaridze⁵⁰, E.G. Tskhadadze^{53a}, K.M. Tsui^{61a}, I.I. Tsukerman⁹⁷, V. Tsulaia¹⁶, S. Tsuno⁶⁷, D. Tsybychev¹⁴⁸, A. Tudorache^{28b}, V. Tudorache^{28b}, A.N. Tuna⁵⁸, S.A. Tupputi^{22a,22b}, S. Turchikhin^{99,al}, D. Turecek¹²⁸, D. Turgeman¹⁷¹, R. Turra^{92a,92b}, A.J. Turvey⁴², P.M. Tuts³⁷, M. Tyndel¹³¹, G. Ucchielli^{22a,22b}, I. Ueda¹⁵⁵, M. Ughetto^{146a,146b}, F. Ukegawa¹⁶⁰, G. Unal³², A. Undrus²⁷, G. Unel¹⁶², F.C. Ungaro⁸⁹, Y. Unno⁶⁷, C. Unverdorben¹⁰⁰, J. Urban^{144b}, P. Urquijo⁸⁹, P. Urrejola⁸⁴, G. Usai⁸, A. Usanova⁶³, L. Vacavant⁸⁶, V. Vacek¹²⁸, B. Vachon⁸⁸, C. Valderanis¹⁰⁰, E. Valdes Santurio^{146a,146b}, N. Valencic¹⁰⁷, S. Valentini^{22a,22b}, A. Valero¹⁶⁶, L. Valery¹³, S. Valkar¹²⁹,

S. Vallecorsa⁵¹, J.A. Valls Ferrer¹⁶⁶, W. Van Den Wollenberg¹⁰⁷, P.C. Van Der Deijl¹⁰⁷,
 R. van der Geer¹⁰⁷, H. van der Graaf¹⁰⁷, N. van Eldik¹⁵², P. van Gemmeren⁶, J. Van Nieuwkoop¹⁴²,
 I. van Vulpen¹⁰⁷, M.C. van Woerden³², M. Vanadia^{132a,132b}, W. Vandelli³², R. Vanguri¹²²,
 A. Vaniachine¹³⁰, P. Vankov¹⁰⁷, G. Vardanyan¹⁷⁶, R. Vari^{132a}, E.W. Varnes⁷, T. Varol⁴², D. Varouchas⁸¹,
 A. Vartapetian⁸, K.E. Varvell¹⁵⁰, J.G. Vasquez¹⁷⁵, F. Vazeille³⁶, T. Vazquez Schroeder⁸⁸, J. Veatch⁵⁶,
 L.M. Veloce¹⁵⁸, F. Veloso^{126a,126c}, S. Veneziano^{132a}, A. Ventura^{74a,74b}, M. Venturi¹⁶⁸, N. Venturi¹⁵⁸,
 A. Venturini²⁵, V. Vercesi^{121a}, M. Verducci^{132a,132b}, W. Verkerke¹⁰⁷, J.C. Vermeulen¹⁰⁷, A. Vest^{46,aq},
 M.C. Vetterli^{142,d}, O. Viazlo⁸², I. Vichou¹⁶⁵, T. Vickey¹³⁹, O.E. Vickey Boeriu¹³⁹, G.H.A. Viehhauser¹²⁰,
 S. Viel¹⁶, L. Vigani¹²⁰, M. Villa^{22a,22b}, M. Villaplana Perez^{92a,92b}, E. Vilucchi⁴⁹, M.G. Vinciter³¹,
 V.B. Vinogradov⁶⁶, C. Vittori^{22a,22b}, I. Vivarelli¹⁴⁹, S. Vlachos¹⁰, M. Vlasak¹²⁸, M. Vogel¹⁷⁴, P. Vokac¹²⁸,
 G. Volpi^{124a,124b}, M. Volpi⁸⁹, H. von der Schmitt¹⁰¹, E. von Toerne²³, V. Vorobel¹²⁹, K. Vorobev⁹⁸,
 M. Vos¹⁶⁶, R. Voss³², J.H. Vosseveld⁷⁵, N. Vranjes¹⁴, M. Vranjes Milosavljevic¹⁴, V. Vrba¹²⁷,
 M. Vreeswijk¹⁰⁷, R. Vuillermet³², I. Vukotic³³, Z. Vykydal¹²⁸, P. Wagner²³, W. Wagner¹⁷⁴,
 H. Wahlberg⁷², S. Wahrmund⁴⁶, J. Wakabayashi¹⁰³, J. Walder⁷³, R. Walker¹⁰⁰, W. Walkowiak¹⁴¹,
 V. Wallangen^{146a,146b}, C. Wang^{35c}, C. Wang^{35d,86}, F. Wang¹⁷², H. Wang¹⁶, H. Wang⁴², J. Wang⁴⁴,
 J. Wang¹⁵⁰, K. Wang⁸⁸, R. Wang⁶, S.M. Wang¹⁵¹, T. Wang²³, T. Wang³⁷, W. Wang^{35b}, X. Wang¹⁷⁵,
 C. Wanotayaroj¹¹⁶, A. Warburton⁸⁸, C.P. Ward³⁰, D.R. Wardrope⁷⁹, A. Washbrook⁴⁸, P.M. Watkins¹⁹,
 A.T. Watson¹⁹, M.F. Watson¹⁹, G. Watts¹³⁸, S. Watts⁸⁵, B.M. Waugh⁷⁹, S. Webb⁸⁴, M.S. Weber¹⁸,
 S.W. Weber¹⁷³, J.S. Webster⁶, A.R. Weidberg¹²⁰, B. Weinert⁶², J. Weingarten⁵⁶, C. Weiser⁵⁰,
 H. Weits¹⁰⁷, P.S. Wells³², T. Wenaus²⁷, T. Wengler³², S. Wenig³², N. Wermes²³, M. Werner⁵⁰,
 M.D. Werner⁶⁵, P. Werner³², M. Wessels^{59a}, J. Wetter¹⁶¹, K. Whalen¹¹⁶, N.L. Whallon¹³⁸,
 A.M. Wharton⁷³, A. White⁸, M.J. White¹, R. White^{34b}, D. Whiteson¹⁶², F.J. Wickens¹³¹,
 W. Wiedenmann¹⁷², M. Wieler¹³¹, P. Wienemann²³, C. Wigglesworth³⁸, L.A.M. Wiik-Fuchs²³,
 A. Wildauer¹⁰¹, F. Wilk⁸⁵, H.G. Wilkens³², H.H. Williams¹²², S. Williams¹⁰⁷, C. Willis⁹¹, S. Willocq⁸⁷,
 J.A. Wilson¹⁹, I. Wingerter-Seez⁵, F. Winklmeier¹¹⁶, O.J. Winston¹⁴⁹, B.T. Winter²³, M. Wittgen¹⁴³,
 J. Wittkowski¹⁰⁰, T.M.H. Wolf¹⁰⁷, M.W. Wolter⁴¹, H. Wolters^{126a,126c}, S.D. Worm¹³¹, B.K. Wosiek⁴¹,
 J. Wotschack³², M.J. Woudstra⁸⁵, K.W. Wozniak⁴¹, M. Wu⁵⁷, M. Wu³³, S.L. Wu¹⁷², X. Wu⁵¹, Y. Wu⁹⁰,
 T.R. Wyatt⁸⁵, B.M. Wynne⁴⁸, S. Xella³⁸, D. Xu^{35a}, L. Xu²⁷, B. Yabsley¹⁵⁰, S. Yacoob^{145a}, R. Yakabe⁶⁸,
 D. Yamaguchi¹⁵⁷, Y. Yamaguchi¹¹⁸, A. Yamamoto⁶⁷, S. Yamamoto¹⁵⁵, T. Yamanaka¹⁵⁵, K. Yamauchi¹⁰³,
 Y. Yamazaki⁶⁸, Z. Yan²⁴, H. Yang^{35e}, H. Yang¹⁷², Y. Yang¹⁵¹, Z. Yang¹⁵, W.-M. Yao¹⁶, Y.C. Yap⁸¹,
 Y. Yasu⁶⁷, E. Yatsenko⁵, K.H. Yau Wong²³, J. Ye⁴², S. Ye²⁷, I. Yeletsikh⁶⁶, A.L. Yen⁵⁸, E. Yildirim⁸⁴,
 K. Yorita¹⁷⁰, R. Yoshida⁶, K. Yoshihara¹²², C. Young¹⁴³, C.J.S. Young³², S. Youssef²⁴, D.R. Yu¹⁶, J. Yu⁸,
 J.M. Yu⁹⁰, J. Yu⁶⁵, L. Yuan⁶⁸, S.P.Y. Yuen²³, I. Yusuff^{30,ar}, B. Zabinski⁴¹, R. Zaidan^{35d}, A.M. Zaitsev^{130,ae},
 N. Zakharchuk⁴⁴, J. Zalieckas¹⁵, A. Zaman¹⁴⁸, S. Zambito⁵⁸, L. Zanello^{132a,132b}, D. Zanzi⁸⁹,
 C. Zeitnitz¹⁷⁴, M. Zeman¹²⁸, A. Zemla^{40a}, J.C. Zeng¹⁶⁵, Q. Zeng¹⁴³, K. Zengel²⁵, O. Zenin¹³⁰,
 T. Ženiš^{144a}, D. Zerwas¹¹⁷, D. Zhang⁹⁰, F. Zhang¹⁷², G. Zhang^{35b,am}, H. Zhang^{35c}, J. Zhang⁶, L. Zhang⁵⁰,
 R. Zhang²³, R. Zhang^{35b,as}, X. Zhang^{35d}, Z. Zhang¹¹⁷, X. Zhao⁴², Y. Zhao^{35d}, Z. Zhao^{35b},
 A. Zhemchugov⁶⁶, J. Zhong¹²⁰, B. Zhou⁹⁰, C. Zhou⁴⁷, L. Zhou³⁷, L. Zhou⁴², M. Zhou¹⁴⁸, N. Zhou^{35f},
 C.G. Zhu^{35d}, H. Zhu^{35a}, J. Zhu⁹⁰, Y. Zhu^{35b}, X. Zhuang^{35a}, K. Zhukov⁹⁶, A. Zibell¹⁷³, D. Zieminska⁶²,
 N.I. Zimine⁶⁶, C. Zimmermann⁸⁴, S. Zimmermann⁵⁰, Z. Zinonos⁵⁶, M. Zinser⁸⁴, M. Ziolkowski¹⁴¹,
 L. Živković¹⁴, G. Zobernig¹⁷², A. Zoccoli^{22a,22b}, M. zur Nedden¹⁷, L. Zwalinski³²

¹ Department of Physics, University of Adelaide, Adelaide, Australia

² Physics Department, SUNY Albany, Albany, NY, United States

³ Department of Physics, University of Alberta, Edmonton, AB, Canada

⁴ (a) Department of Physics, Ankara University, Ankara; (b) Istanbul Aydin University, Istanbul; (c) Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey

⁵ LAPP, CNRS/IN2P3 and Université Savoie Mont Blanc, Annecy-le-Vieux, France

⁶ High Energy Physics Division, Argonne National Laboratory, Argonne, IL, United States

⁷ Department of Physics, University of Arizona, Tucson, AZ, United States

⁸ Department of Physics, The University of Texas at Arlington, Arlington, TX, United States

⁹ Physics Department, University of Athens, Athens, Greece

¹⁰ Physics Department, National Technical University of Athens, Zografou, Greece

¹¹ Department of Physics, The University of Texas at Austin, Austin, TX, United States

¹² Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan

¹³ Institut de Física d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology, Barcelona, Spain

¹⁴ Institute of Physics, University of Belgrade, Belgrade, Serbia

¹⁵ Department for Physics and Technology, University of Bergen, Bergen, Norway

¹⁶ Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, CA, United States

- ¹⁷ Department of Physics, Humboldt University, Berlin, Germany
- ¹⁸ Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland
- ¹⁹ School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom
- ²⁰ ^(a) Department of Physics, Bogazici University, Istanbul; ^(b) Department of Physics Engineering, Gaziantep University, Gaziantep; ^(d) Istanbul Bilgi University, Faculty of Engineering and Natural Sciences, Istanbul; ^(e) Bahcesehir University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey
- ²¹ Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia
- ²² ^(a) INFN Sezione di Bologna; ^(b) Dipartimento di Fisica e Astronomia, Università di Bologna, Bologna, Italy
- ²³ Physikalisches Institut, University of Bonn, Bonn, Germany
- ²⁴ Department of Physics, Boston University, Boston, MA, United States
- ²⁵ Department of Physics, Brandeis University, Waltham, MA, United States
- ²⁶ ^(a) Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro; ^(b) Electrical Circuits Department, Federal University of Juiz de Fora (UFJF), Juiz de Fora; ^(c) Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei; ^(d) Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil
- ²⁷ Physics Department, Brookhaven National Laboratory, Upton, NY, United States
- ²⁸ ^(a) Transilvania University of Brasov, Brasov, Romania; ^(b) National Institute of Physics and Nuclear Engineering, Bucharest; ^(c) National Institute for Research and Development of Isotopic and Molecular Technologies, Physics Department, Cluj Napoca; ^(d) University Politehnica Bucharest, Bucharest; ^(e) West University in Timisoara, Timisoara, Romania
- ²⁹ Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina
- ³⁰ Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom
- ³¹ Department of Physics, Carleton University, Ottawa, ON, Canada
- ³² CERN, Geneva, Switzerland
- ³³ Enrico Fermi Institute, University of Chicago, Chicago, IL, United States
- ³⁴ ^(a) Departamento de Física, Pontificia Universidad Católica de Chile, Santiago; ^(b) Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile
- ³⁵ ^(a) Institute of High Energy Physics, Chinese Academy of Sciences, Beijing; ^(b) Department of Modern Physics, University of Science and Technology of China, Anhui; ^(c) Department of Physics, Nanjing University, Jiangsu; ^(d) School of Physics, Shandong University, Shandong; ^(e) Department of Physics and Astronomy, Shanghai Key Laboratory for Particle Physics and Cosmology, Shanghai Jiao Tong University, Shanghai; ^(f) Physics Department, Tsinghua University, Beijing 100084, China
- ³⁶ Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Clermont-Ferrand, France
- ³⁷ Nevis Laboratory, Columbia University, Irvington, NY, United States
- ³⁸ Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark
- ³⁹ ^(a) INFN Gruppo Collegato di Cosenza, Laboratori Nazionali di Frascati; ^(b) Dipartimento di Fisica, Università della Calabria, Rende, Italy
- ⁴⁰ ^(a) AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow; ^(b) Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland
- ⁴¹ Institute of Nuclear Physics Polish Academy of Sciences, Krakow, Poland
- ⁴² Physics Department, Southern Methodist University, Dallas, TX, United States
- ⁴³ Physics Department, University of Texas at Dallas, Richardson, TX, United States
- ⁴⁴ DESY, Hamburg and Zeuthen, Germany
- ⁴⁵ Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany
- ⁴⁶ Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden, Germany
- ⁴⁷ Department of Physics, Duke University, Durham, NC, United States
- ⁴⁸ SUPA – School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom
- ⁴⁹ INFN Laboratori Nazionali di Frascati, Frascati, Italy
- ⁵⁰ Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany
- ⁵¹ Section de Physique, Université de Genève, Geneva, Switzerland
- ⁵² ^(a) INFN Sezione di Genova; ^(b) Dipartimento di Fisica, Università di Genova, Genova, Italy
- ⁵³ ^(a) E. Andronikashvili Institute of Physics, Iv. Javakishvili Tbilisi State University, Tbilisi; ^(b) High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia
- ⁵⁴ II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany
- ⁵⁵ SUPA – School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom
- ⁵⁶ II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany
- ⁵⁷ Laboratoire de Physique Subatomique et de Cosmologie, Université Grenoble-Alpes, CNRS/IN2P3, Grenoble, France
- ⁵⁸ Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, MA, United States
- ⁵⁹ ^(a) Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg; ^(b) Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg; ^(c) ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany
- ⁶⁰ Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan
- ⁶¹ ^(a) Department of Physics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong; ^(b) Department of Physics, The University of Hong Kong, Hong Kong; ^(c) Department of Physics, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, China
- ⁶² Department of Physics, Indiana University, Bloomington, IN, United States
- ⁶³ Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria
- ⁶⁴ University of Iowa, Iowa City, IA, United States
- ⁶⁵ Department of Physics and Astronomy, Iowa State University, Ames, IA, United States
- ⁶⁶ Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia
- ⁶⁷ KEK, High Energy Accelerator Research Organization, Tsukuba, Japan
- ⁶⁸ Graduate School of Science, Kobe University, Kobe, Japan
- ⁶⁹ Faculty of Science, Kyoto University, Kyoto, Japan
- ⁷⁰ Kyoto University of Education, Kyoto, Japan
- ⁷¹ Department of Physics, Kyushu University, Fukuoka, Japan
- ⁷² Instituto de Fisica La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina
- ⁷³ Physics Department, Lancaster University, Lancaster, United Kingdom
- ⁷⁴ ^(a) INFN Sezione di Lecce; ^(b) Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy
- ⁷⁵ Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom
- ⁷⁶ Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia
- ⁷⁷ School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom
- ⁷⁸ Department of Physics, Royal Holloway University of London, Surrey, United Kingdom
- ⁷⁹ Department of Physics and Astronomy, University College London, London, United Kingdom
- ⁸⁰ Louisiana Tech University, Ruston, LA, United States
- ⁸¹ Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France
- ⁸² Fysiska institutionen, Lunds universitet, Lund, Sweden
- ⁸³ Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain
- ⁸⁴ Institut für Physik, Universität Mainz, Mainz, Germany
- ⁸⁵ School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom
- ⁸⁶ CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
- ⁸⁷ Department of Physics, University of Massachusetts, Amherst, MA, United States

- ⁸⁸ Department of Physics, McGill University, Montreal, QC, Canada
- ⁸⁹ School of Physics, University of Melbourne, Victoria, Australia
- ⁹⁰ Department of Physics, The University of Michigan, Ann Arbor, MI, United States
- ⁹¹ Department of Physics and Astronomy, Michigan State University, East Lansing, MI, United States
- ⁹² ^(a) INFN Sezione di Milano; ^(b) Dipartimento di Fisica, Università di Milano, Milano, Italy
- ⁹³ B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Belarus
- ⁹⁴ National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Belarus
- ⁹⁵ Group of Particle Physics, University of Montreal, Montreal, QC, Canada
- ⁹⁶ P.N. Lebedev Physical Institute of the Russian Academy of Sciences, Moscow, Russia
- ⁹⁷ Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia
- ⁹⁸ National Research Nuclear University MEPhI, Moscow, Russia
- ⁹⁹ D.V. Skobeltsyn Institute of Nuclear Physics, M.V. Lomonosov Moscow State University, Moscow, Russia
- ¹⁰⁰ Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany
- ¹⁰¹ Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany
- ¹⁰² Nagasaki Institute of Applied Science, Nagasaki, Japan
- ¹⁰³ Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan
- ¹⁰⁴ ^(a) INFN Sezione di Napoli; ^(b) Dipartimento di Fisica, Università di Napoli, Napoli, Italy
- ¹⁰⁵ Department of Physics and Astronomy, University of New Mexico, Albuquerque, NM, United States
- ¹⁰⁶ Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands
- ¹⁰⁷ Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands
- ¹⁰⁸ Department of Physics, Northern Illinois University, DeKalb, IL, United States
- ¹⁰⁹ Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia
- ¹¹⁰ Department of Physics, New York University, New York, NY, United States
- ¹¹¹ Ohio State University, Columbus, OH, United States
- ¹¹² Faculty of Science, Okayama University, Okayama, Japan
- ¹¹³ Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, OK, United States
- ¹¹⁴ Department of Physics, Oklahoma State University, Stillwater, OK, United States
- ¹¹⁵ Palacký University, RCPTM, Olomouc, Czech Republic
- ¹¹⁶ Center for High Energy Physics, University of Oregon, Eugene, OR, United States
- ¹¹⁷ LAL, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, France
- ¹¹⁸ Graduate School of Science, Osaka University, Osaka, Japan
- ¹¹⁹ Department of Physics, University of Oslo, Oslo, Norway
- ¹²⁰ Department of Physics, Oxford University, Oxford, United Kingdom
- ¹²¹ ^(a) INFN Sezione di Pavia; ^(b) Dipartimento di Fisica, Università di Pavia, Pavia, Italy
- ¹²² Department of Physics, University of Pennsylvania, Philadelphia, PA, United States
- ¹²³ National Research Centre "Kurchatov Institute" B.P. Konstantinov Petersburg Nuclear Physics Institute, St. Petersburg, Russia
- ¹²⁴ ^(a) INFN Sezione di Pisa; ^(b) Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy
- ¹²⁵ Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, PA, United States
- ¹²⁶ ^(a) Laboratório de Instrumentação e Física Experimental de Partículas – LIP, Lisboa; ^(b) Faculdade de Ciências, Universidade de Lisboa, Lisboa; ^(c) Department of Physics, University of Coimbra, Coimbra; ^(d) Centro de Física Nuclear da Universidade de Lisboa, Lisboa; ^(e) Departamento de Física, Universidade do Minho, Braga; ^(f) Departamento de Física Teórica y del Cosmos and CAFPE, Universidad de Granada, Granada (Spain); ^(g) Dep Física and CEFITEC de Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal
- ¹²⁷ Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic
- ¹²⁸ Czech Technical University in Prague, Praha, Czech Republic
- ¹²⁹ Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic
- ¹³⁰ State Research Center Institute for High Energy Physics (Protvino), NRC KI, Russia
- ¹³¹ Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom
- ¹³² ^(a) INFN Sezione di Roma; ^(b) Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy
- ¹³³ ^(a) INFN Sezione di Roma Tor Vergata; ^(b) Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy
- ¹³⁴ ^(a) INFN Sezione di Roma Tre; ^(b) Dipartimento di Matematica e Fisica, Università Roma Tre, Roma, Italy
- ¹³⁵ ^(a) Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies – Université Hassan II, Casablanca; ^(b) Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat; ^(c) Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech; ^(d) Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda; ^(e) Faculté des sciences, Université Mohammed V, Rabat, Morocco
- ¹³⁶ DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique et aux Energies Alternatives), Gif-sur-Yvette, France
- ¹³⁷ Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, CA, United States
- ¹³⁸ Department of Physics, University of Washington, Seattle, WA, United States
- ¹³⁹ Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom
- ¹⁴⁰ Department of Physics, Shinshu University, Nagano, Japan
- ¹⁴¹ Fachbereich Physik, Universität Siegen, Siegen, Germany
- ¹⁴² Department of Physics, Simon Fraser University, Burnaby, BC, Canada
- ¹⁴³ SLAC National Accelerator Laboratory, Stanford, CA, United States
- ¹⁴⁴ ^(a) Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava; ^(b) Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic
- ¹⁴⁵ ^(a) Department of Physics, University of Cape Town, Cape Town; ^(b) Department of Physics, University of Johannesburg, Johannesburg; ^(c) School of Physics, University of the Witwatersrand, Johannesburg, South Africa
- ¹⁴⁶ ^(a) Department of Physics, Stockholm University; ^(b) The Oskar Klein Centre, Stockholm, Sweden
- ¹⁴⁷ Physics Department, Royal Institute of Technology, Stockholm, Sweden
- ¹⁴⁸ Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook, NY, United States
- ¹⁴⁹ Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom
- ¹⁵⁰ School of Physics, University of Sydney, Sydney, Australia
- ¹⁵¹ Institute of Physics, Academia Sinica, Taipei, Taiwan
- ¹⁵² Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel
- ¹⁵³ Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel
- ¹⁵⁴ Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece
- ¹⁵⁵ International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan
- ¹⁵⁶ Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan
- ¹⁵⁷ Department of Physics, Tokyo Institute of Technology, Tokyo, Japan
- ¹⁵⁸ Department of Physics, University of Toronto, Toronto, ON, Canada
- ¹⁵⁹ ^(a) TRIUMF, Vancouver, BC; ^(b) Department of Physics and Astronomy, York University, Toronto, ON, Canada
- ¹⁶⁰ Faculty of Pure and Applied Sciences, and Center for Integrated Research in Fundamental Science and Engineering, University of Tsukuba, Tsukuba, Japan

- ¹⁶¹ Department of Physics and Astronomy, Tufts University, Medford, MA, United States
¹⁶² Department of Physics and Astronomy, University of California Irvine, Irvine, CA, United States
¹⁶³ ^(a) INFN Gruppo Collegato di Udine, Sezione di Trieste, Udine; ^(b) ICTP, Trieste; ^(c) Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy
¹⁶⁴ Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden
¹⁶⁵ Department of Physics, University of Illinois, Urbana, IL, United States
¹⁶⁶ Instituto de Física Corpuscular (IFIC) and Departamento de Física Atómica, Molecular y Nuclear and Departamento de Ingeniería Electrónica and Instituto de Microelectrónica de Barcelona (IMB-CNM), University of Valencia and CSIC, Valencia, Spain
¹⁶⁷ Department of Physics, University of British Columbia, Vancouver, BC, Canada
¹⁶⁸ Department of Physics and Astronomy, University of Victoria, Victoria, BC, Canada
¹⁶⁹ Department of Physics, University of Warwick, Coventry, United Kingdom
¹⁷⁰ Waseda University, Tokyo, Japan
¹⁷¹ Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel
¹⁷² Department of Physics, University of Wisconsin, Madison, WI, United States
¹⁷³ Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany
¹⁷⁴ Fakultät für Mathematik und Naturwissenschaften, Fachgruppe Physik, Bergische Universität Wuppertal, Wuppertal, Germany
¹⁷⁵ Department of Physics, Yale University, New Haven, CT, United States
¹⁷⁶ Yerevan Physics Institute, Yerevan, Armenia
¹⁷⁷ Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Villeurbanne, France

- ^a Also at Department of Physics, King's College London, London, United Kingdom.
^b Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.
^c Also at Novosibirsk State University, Novosibirsk, Russia.
^d Also at TRIUMF, Vancouver, BC, Canada.
^e Also at Department of Physics & Astronomy, University of Louisville, Louisville, KY, United States.
^f Also at Department of Physics, California State University, Fresno, CA, United States.
^g Also at Department of Physics, University of Fribourg, Fribourg, Switzerland.
^h Also at Departament de Física de la Universitat Autònoma de Barcelona, Barcelona, Spain.
ⁱ Also at Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Portugal.
^j Also at Tomsk State University, Tomsk, Russia.
^k Also at Università di Napoli Parthenope, Napoli, Italy.
^l Also at Institute of Particle Physics (IPP), Canada.
^m Also at National Institute of Physics and Nuclear Engineering, Bucharest, Romania.
ⁿ Also at Department of Physics, St. Petersburg State Polytechnical University, St. Petersburg, Russia.
^o Also at Department of Physics, The University of Michigan, Ann Arbor, MI, United States.
^p Also at Centre for High Performance Computing, CSIR Campus, Rosebank, Cape Town, South Africa.
^q Also at Louisiana Tech University, Ruston, LA, United States.
^r Also at Institutio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona, Spain.
^s Also at Graduate School of Science, Osaka University, Osaka, Japan.
^t Also at Department of Physics, National Tsing Hua University, Taiwan.
^u Also at Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands.
^v Also at Department of Physics, The University of Texas at Austin, Austin, TX, United States.
^w Also at Institute of Theoretical Physics, Ilia State University, Tbilisi, Georgia.
^x Also at CERN, Geneva, Switzerland.
^y Also at Georgian Technical University (GTU), Tbilisi, Georgia.
^z Also at Ochadai Academic Production, Ochanomizu University, Tokyo, Japan.
^{aa} Also at Manhattan College, New York, NY, United States.
^{ab} Also at Hellenic Open University, Patras, Greece.
^{ac} Also at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.
^{ad} Also at School of Physics, Shandong University, Shandong, China.
^{ae} Also at Moscow Institute of Physics and Technology State University, Dolgoprudny, Russia.
^{af} Also at Section de Physique, Université de Genève, Geneva, Switzerland.
^{ag} Also at Eotvos Lorand University, Budapest, Hungary.
^{ah} Also at International School for Advanced Studies (SISSA), Trieste, Italy.
^{ai} Also at Department of Physics and Astronomy, University of South Carolina, Columbia, SC, United States.
^{aj} Also at School of Physics and Engineering, Sun Yat-sen University, Guangzhou, China.
^{ak} Also at Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences, Sofia, Bulgaria.
^{al} Also at Faculty of Physics, M.V. Lomonosov Moscow State University, Moscow, Russia.
^{am} Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.
^{an} Also at National Research Nuclear University MEPhI, Moscow, Russia.
^{ao} Also at Department of Physics, Stanford University, Stanford, CA, United States.
^{ap} Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.
^{aq} Also at Flensburg University of Applied Sciences, Flensburg, Germany.
^{ar} Also at University of Malaya, Department of Physics, Kuala Lumpur, Malaysia.
^{as} Also at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.
^{at} Also affiliated with PKU-CHEP.
^{*} Deceased.